

Effective Use of Simulations for the Teaching and Acquisition of Veterinary Professional and Clinical Skills

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ABSTRACT

Simulation technology will feature prominently in this exciting, yet challenging, time for veterinary medicine. The profession is evolving to keep pace with rapid changes in clinical practice, scientific discovery, and educational strategy, while ensuring that it follows the public mandate to produce competent veterinarians. Among the challenges to meeting this educational goal are limitations—due to important issues such as animal welfare—on the availability of real patients for training. Drawing chiefly on the experience in human medicine, this article explores the use of simulations in veterinary medical education to provide safe and ethical alternative opportunities for learners to practice essential clinical and professional skills.

INTRODUCTION

Health professions education during the past two decades has witnessed a significant increase in the use of simulation technology for teaching and assessment. This has been true particularly in the realm of human medicine (encompassing the training and evaluation of physicians, dentists, and allied health professionals such as nurses, physical therapists, paramedics, etc.), while veterinary medicine only more recently has begun to embrace these simulation modalities. A discussion of these differing trends is the focus of this article. We will begin first with a general consideration of the uses of simulation for training, including non-medical high-stakes performance fields, and then move more specifically to the medical domains, describing both the parallel and the divergent forces in human and veterinary medical education that influence the use of simulation technology. Of particular importance in the veterinary context, such discussion necessarily includes the issues of animal welfare and competency-based education. Although limited in number, we highlight specific simulation methods already applied in veterinary school curricula, and we offer suggestions toward the further development of simulation technology throughout veterinary medical education.

A logical starting point for the discussion is a definition of what we mean by the term *simulation*. A medical simulation, broadly defined, is a device or set of conditions that aims to imitate real patients, anatomic regions, or clinical tasks, and/or to mirror the real life situations in which medical services are rendered. A *simulator*, more narrowly defined, is a simulation *device*; for most of this discussion, we will use the terms interchangeably. Simulations can take many forms and span the range from low- to high-fidelity (*fidelity* refers to the exactness of duplication) and from devices for individual users to role-playing scenarios for groups of trainees. These include simple, three-dimensional, but inert anatomic models and single task trainers, such as venipuncture arms and endotracheal intubation mannequins; computer-based programs and standardized patient (SP) sessions that simulate patient encounters; virtual

reality *haptic* systems that provide tactile feedback for training in examination, surgical, and endoscopic procedures; high-fidelity examination simulators, such as “Harvey,” the Cardiopulmonary Patient Simulator,¹ that provide very realistic physical findings but still are not interactive; and full-body mannequins that provide physical findings and actually respond to user actions. The learner is required to react to the simulation as he or she would under real-life circumstances; of course, we realize that a simulation is never completely identical to “the real thing.” Some reasons are obvious: engineering limitations, psychometric requirements, and cost and time constraints.² Nonetheless, technological advances that have led to higher-fidelity simulations have been a significant contributor to the recent rise in the use of simulation technology throughout medical education.

Disciplines other than the health care professions much earlier recognized the potential of simulation technology for skills training and now have well-established programs utilizing simulation modalities. Examples include the use of flight simulators for pilots and astronauts, war games and training exercises for military personnel, management games for business executives, and technical operations scenarios for nuclear power plant personnel. Such simulations improve skills acquisition by placing trainees in lifelike situations and by providing immediate answers to questions and feedback about decisions and actions; for example, flight simulators can realistically mimic in-flight situations and the aviation industry has demonstrated that such training improves pilot skills.¹

INFLUENCES DRIVING THE USE OF SIMULATION IN HEALTH PROFESSIONS EDUCATION

Multiple factors have contributed to the increasing use of simulation technology in medical education. These include technological progress in diagnosis and treatment, such as newer imaging modalities and endoscopic procedures. Although more commonly applied in human medicine,

thoroscopic and laparoscopic techniques, for example, are also gaining wider acceptance in veterinary surgery; these require the development of perceptual and psychomotor skills that are different from traditional approaches and that, therefore, require new methods for teaching and learning.³ Concurrent advances in simulation technology, such as high-tech virtual reality endoscopy trainers, offer novel techniques for such instruction and skills acquisition.

In addition, changes in health care delivery have resulted in shorter hospital stays and clinic visits, greater numbers of patients, and higher acuity of illnesses; at academic medical centers, this has resulted in the reduced availability of patients as learning opportunities, as well as a decrease in teaching time for clinical faculty.^{1,4} Similar challenges arise at schools of veterinary medicine: The operational philosophy of teaching hospitals, whereby they accept only "good teaching cases," offers the advantage of a student-centered educational experience but the disadvantage of a limited number and variety of patients. Simulators, by contrast, can be readily available at any time and can reproduce a wide variety of clinical conditions and situations on demand; unlike real patients, simulators do not become tired or embarrassed or behave unpredictably and, therefore, they provide a standardized experience for all trainees.

The issue of patient safety has provided another important impetus to the development and implementation of simulation technology. Recent reports⁵⁻⁸ have focused attention on the problem of medical errors and have called for improvement in (human) patient safety, not only through prevention of mistakes by individuals but also through the correction of faults in the systems of care.⁹ One response to this summons has been the greater use of simulation tools for medical education, especially for teaching about rare and/or critical incidents. Trainees can make mistakes and learn to recognize and correct them in the simulated environment, without fear of punishment or of harm to real patients. Adopting the model from aviation, with its high-risk performance environment, specialties like anesthesiology, critical care, and emergency medicine have successfully incorporated simulation technology into their training programs, not only to develop individual skills but also to teach effective collaboration in teams and to build a culture of safety.

Closely related to safety issues are important ethical questions about the appropriateness of "using" patients as educational resources. Such debate often centers on instructional settings that involve sensitive tasks (e.g., pelvic examination) or risk of harm to patients (e.g., endotracheal intubation). Analogous considerations in veterinary medicine focus increasingly and altogether appropriately on animal welfare. Such ethical concerns now make unavailable many of the approaches used previously for the teaching and learning of veterinary clinical skills; for example, survival surgeries now have replaced the terminal surgeries of the past. These animal welfare issues also have affected human medical education, where we are replacing the animal models previously used to train medical students and physicians in certain clinical skills with other methods, including simulations that offer safe and ethical alternatives for training.

COMPETENCY-BASED EDUCATION AND DELIBERATE PRACTICE

"While student learning is clearly the goal of education, there is a pressing need to provide evidence that learning or mastery actually occurs."¹⁰ This statement reflects a worldwide shift in focus toward outcomes-based education. This paradigm change derives in part from attempts by academic institutions and professional organizations to self-regulate and set standards for quality assurance, but chiefly it represents a response to public demand for assurance that doctors are competent: "There is a societal expectation that veterinarians everywhere will all have graduated at the same standard and have the same basic competencies."¹¹ Both human and veterinary medical education have established accreditation bodies to recognize institutions that maintain those standards requisite for their graduates to achieve credentials for professional practice. For undergraduate veterinary programs, the American Veterinary Medical Association's Council on Education (COE) has recently adopted "outcomes assessment" as their eleventh standard of accreditation.¹² This standard requires schools to evaluate their students' performance and to demonstrate that they are competent upon graduation. In addition, although it does not mandate specific outcome measures, the COE has recently established a minimally acceptable level of performance on the North American Veterinary Licensure Examination (NAVLE) as one benchmark; thus, although the exam consists only of multiple-choice questions, without clinical skills testing, the NAVLE is currently the only direct, nationally comparable veterinary outcomes measure.¹⁰

What may be the effects of developing such standards on veterinary school curricula? Reviews have shown a correlation between the introduction of new testing and accreditation requirements and medical schools' adoption of related educational reforms.^{13,14} For example, the US Medical Licensure Examination (USMLE) recently added a new testing component, the Step 2 Clinical Skills (CS) examination; because this employs simulated patients (SPs) for medical students to interview and examine, sequelae of this change in testing requirements include greater use of SP training sessions in medical schools and the construction of dedicated clinical skills simulation centers. In similar fashion, the new NAVLE performance benchmark and COE assessment standard for accreditation may lead to curricular change in veterinary schools. A clinical skills component, analogous to the USMLE Step 2 CS examination, may be an appropriate addition to the NAVLE assessment, which in turn may lead to greater use of simulation for training in veterinary medicine.

Viewed from the perspective of competency-based education, however, the fact that fewer learning opportunities are afforded by patients in the traditional clinical curriculum becomes problematic. The various influences discussed earlier—changes in health care delivery, concerns for patient safety, and ethical considerations—all tend to decrease trainees' opportunities "to practice" their professional and clinical skills. The significance of this trend is enormous because the most important identifiable factor in distinguishing among levels of professional performance, especially in achieving expertise or mastery in a particular field, is the amount of "deliberate practice."¹⁵ This concept

refers to intense, repetitive performance, in a controlled setting, of intended cognitive or psychomotor skills within a focused domain; rigorous skills assessment to identify deficiencies and errors; specific, informative feedback on how to correct them; and ongoing practice, with progressive increases in level of difficulty, yielding gradual, continuous improvement in skills performance. Research has demonstrated the effects of deliberate practice on attaining mastery or expert status in many professional domains, including chess, athletics, music, and medicine.¹⁶

The typical veterinary curriculum further compounds this problem that practice opportunities with real patients are limited. In contrast to the educational program in human medicine, where nearly all medical school graduates continue on to residency/fellowship training in various specialties (a minimum of three additional years of clinical experience), the majority (~70%) of graduates with the DVM or equivalent degree go directly into clinical practice, often in an apprenticeship or junior partnership arrangement. Educators speak of the need for "omnicompetent graduates from veterinary schools,"¹⁷ but are the usual 12-to-18 months of clinical training time enough to acquire the wide range of skills, some involving invasive treatments, expected of practicing veterinarians? There is some evidence that the answer to this question is, "No." University of California (Davis) School of Veterinary Medicine researchers first defined a set of 62 attributes, including 22 involving a range of clinical skills, that their students were expected to have demonstrated prior to graduation.¹⁸ They then designed an outcomes assessment tool, in the form of a survey distributed to several thousand practicing California veterinarians, to determine whether recent graduates were meeting these expectations when they joined clinical practices. Survey respondents indicated that several areas of clinical training needed more attention, including the development of surgical and other procedural skills.¹⁹ Another study from the Ontario (Canada) Veterinary College surveyed students and recent alumni to determine their perceptions of their own technical and professional skills based on preparation received in veterinary school. Most study participants felt that they had not received adequate instruction in professional skills (especially regarding communication, interpersonal, and emotional issues); for example, many students did not feel competent or comfortable delivering bad news, dealing with demanding clients, or practicing euthanasia.²⁰

How then, with various forces tending to limit the use of patients as educational resources and such a small window of clinical training time, can veterinary students practice these skills enough to achieve at least minimally acceptable standards of proficiency, much less mastery in their profession? *There is ample scholarly evidence from the human medical education literature to support the assertion that simulation technology offers one solution to this problem.* For instance, a cohort study conducted at five academic medical centers compared two groups of fourth-year medical students enrolled in a month-long cardiology elective; one group's training included only customary ward work with real patients, while the other's substituted, for half of the ward experience, training on computer-based modules linked to a cardiology-patient simulator. Outcomes of this research showed that students in the intervention group

acquired nearly twice the core cardiology bedside skills, despite having half the time with actual patients and seeing fewer patients, and required little or no faculty involvement during the intervention.²¹ Earlier research involving the same simulator had already demonstrated that diagnostic skills acquired with the mannequin transferred to real patients, without detectable differences in interpersonal skills, addressing concerns that simulator training might negatively impact behaviors with actual patients.²²

SPECIFIC SIMULATIONS IN VETERINARY MEDICAL EDUCATION

So what currently exists in terms of animal simulators designed specifically for use in veterinary education? The short answer is, "Not enough." Our search of the literature, using MEDLINE (1966 to present), yielded less than a half dozen reports on simulation devices used in veterinary training. A few additional articles reported the use of more general simulation techniques (e.g., simulated clients or computer-based simulations) for veterinary medical education. Smeak and colleagues at the Ohio State University College of Veterinary Medicine did some of the earliest work with simulators for teaching surgical skills.^{23,24} In one study, they used inexpensive hemostasis models to supplement instruction in hand-tied ligation of a bleeding vessel and compared the performance of two groups of paired (acting in turn as surgeon and assistant) first-year veterinary students with no prior hands-on surgical experience. The intervention group viewed a videotape on hemostatic ligature and practiced their technique on a simulator, while the comparison group only viewed the videotape until they felt competent to perform the task on a live animal. Blinded evaluation of both groups' video-recorded performance yielded significantly higher ratings of total psychomotor skill and accuracy for students in the simulator intervention group, who also tended to perform the task more expeditiously.²³ A later study employed a similar design, this time comparing the effects on performing gastrotomy closure of using traditional learning resources alone versus using the same materials plus practicing with a hollow organ simulator. Scoring involved post-hoc analysis of videotaped surgery sessions with live animals and gross examination of harvested stomachs. Outcomes in this study, however, did not demonstrate significant differences in performance (e.g., mean closure time) between the simulator-trained group and the traditionally trained group; nor did prior practice with the model correlate with increased student confidence during the live gastrotomy sessions. The authors suggested that the lack of positive outcomes might have been due to the fact that the hollow organ model did not realistically simulate live stomach tissue (the material was more fragile and stiff).²⁴

More recently, a group from the University of Glasgow (UK) has described their work with virtual reality animal simulators. They have created systems based on the PHANTOM force feedback device,^a a *haptic* interface that provides users with tactile responses to simulate palpation of virtual objects. Using this technology, they have devised simulations for teaching horse ovary palpation²⁵ and bovine rectal palpation.²⁶ Instruction using the latter system, with the PHANTOM device inside a fiberglass model of a cow, was integrated into the fourth-year veterinary curriculum,

and student responses to questionnaires indicated that they considered the haptic training helpful for learning bovine rectal palpation and that using the simulator increased confidence.²⁷ A follow-up study validated teaching with this device: outcomes demonstrated that performance of the real task, when examining cows for the first time, was significantly better in a group of students whose training was supplemented with practice on the simulator than in a group of traditionally trained students.²⁸

Development of simulation devices such as these is one remedy to the identified shortcomings in veterinary training in technical, especially invasive, procedural skills;¹⁹ other simulation methods offer alternatives for teaching the professional communication and interpersonal skills deemed inadequate in current veterinary curricula. For instance, one “virtual veterinary clinic” used online, small-animal case simulations as clinical problem-solving exercises.²⁹ In another example, educators at the same Canadian institution (Ontario), whose students and graduates reported deficiencies in communication skills training,²⁰ have created an innovative learning laboratory, where students practice their interpersonal skills. Modeled on the experience with simulated or standardized patients (SPs) in human medical education, they implemented a program using simulated clients (SCs) and patients in the first-year curriculum.³⁰ Actors played the role of clients in eight different scenarios, scripted to address the learning objectives of the course and to reflect the nuances of veterinarian–client–patient interactions. All interview sessions were videotaped; students then critiqued their own performances and received constructive feedback from peers, SCs, and facilitators. Preliminary informal evaluation of the program yielded very positive comments and indicated satisfaction among students and faculty alike, with students most valuing the high quality and realism of the cases developed for this educational module. The authors deserve credit for their pioneering work in veterinary communication skills training; as they themselves have stated, formal outcomes assessment will be necessary to determine if this simulation program achieves the objective of improved veterinary professional skills acquisition.³⁰

TOWARD FURTHER DEVELOPMENT OF SIMULATION TECHNOLOGY IN VETERINARY EDUCATION

We noted earlier that the simulations described above represent the very few published reports on this technology being employed in veterinary education; a few others that have not reached the referencing in Pub Med are reported in this issue of the *Journal of Veterinary Medical Education*.³¹ Contrast this with the many hundreds of articles in the human medical education literature detailing various applications of these modalities for teaching and learning.³² What accounts for this difference? Certainly, relative fiscal resources are a significant contributor: Veterinary medical education is a much smaller enterprise than its human counterpart—as an illustration, there are 126 US and 16 Canadian medical schools versus only 28 US and 4 Canadian veterinary schools, and each of these has just 10–20% the number of faculty of human medical schools—with correspondingly less funding. Simulators, especially high-fidelity devices utilizing sophisticated

technologies, can be expensive. For new simulators, there are expenditures on initial research and development that can be significant, and then, as also for existing technologies, there are the costs of purchasing, operating, and maintaining the devices. Even for relatively low-tech simulations, such as those utilizing SPs or SCs, there are costs associated with recruiting and training personnel for role-playing, supervision, and evaluation.

One way to circumvent some of these financial obstacles is to avoid “reinventing the wheel.” Adaptation of existing technologies can eliminate some of the initial (often high) costs of research and development. For example, Modell and colleagues³³ report using the Human Patient Simulator^b to train veterinary students during a core clinical clerkship. The simulator consists of a full-sized adult human mannequin and a special computer program that controls values for numerous physiologic parameters; the simulator responds realistically, in an appropriate, dose-related manner, to the administration of anesthetic gases (through an interface with an actual anesthesia machine) and intravenous medications. Obviously, *de novo* development of such sophisticated technology in an animal model would be extremely time- and cost-intensive. Instead, these researchers employed the existing technology with veterinary students to teach induction of anesthesia and how to deal with critical incidents that might arise in this clinical setting. Their results demonstrated significantly higher scores on relevant sections of the clerkship exam for students who received training on the simulator as compared to students who engaged in self-study instead of the simulation exercise. They also observed that students rapidly gained confidence in treating their simulated patients, and this appeared to carry over to the clinical setting when they were anesthetizing live animals. Although some students commented that an animal mannequin would have been more familiar to them, nonetheless, they felt that the experience with a human simulator was directly applicable to their practice. While the researchers acknowledged that it would require substantial reprogramming of existing software to account for the significant inter-species variation among even the more common species encountered in general veterinary practice, they suggested that such adaptation of current technologies to animal models has the potential to provide more realistic veterinary simulations.³³ Another example is the virtual reality system described earlier,^a where investigators converted the same haptic device from a horse ovary palpation simulator to a bovine rectal palpation trainer by placing it inside a fiberglass model of a cow^{25–28}; simply by changing the inexpensive outer shell, one can relatively easily adapt the same advanced simulation system for teaching a variety of clinical tasks.

Despite the allure of such high-tech simulators, decisions by veterinary schools to invest in these tools must also involve consideration of their cost-effectiveness. Educators must match the features and fidelity of the simulator to the training objectives. For example, insertion of a bladder catheter is one skill that learners can practice on the Human Patient Simulator (HPS);^b if the only educational objective is to teach bladder catheterization, however, it makes little sense to purchase the very expensive HPS (~US\$176 K–250 K, depending on features),^c if practice on a far less

costly 3-D anatomic (pelvic) model accomplishes the same goal. On the other hand, acquiring one full-featured device such as the HPS may be more economical than buying multiple single-task trainers to practice, say, endotracheal intubation, the administration and pharmacology of intravenous medications, induction of anesthesia, and so on, if those are the educational objectives. Additional factors to balance include the costs of maintaining the equipment (e.g., the annual service agreement for the HPS is ~US\$7K–11K)^c; the added value of higher face validity (realism) with such a multi-feature simulator; and savings in instructor time, if the simulator allows independent learning.

Having determined the appropriate simulation technology to accomplish the stated training goals, one must also obtain the necessary funding. The recent focus on human patient safety has led to the increased financial sponsorship of medical simulations to improve physician skills and decrease medical errors. Analogous concerns for animal welfare, food safety and public health may lead to greater funding opportunities for the research and development of simulation technologies in veterinary education (e.g., computer-based systems or role-playing scenarios for training responses to outbreaks of food-borne illness). The modern threat of (bio)terrorism and the increasing recognition of the crucial role of “veterinarians [as] the ‘first line of defense’ in biologic attack”³⁴ may also result in more fiscal resources being channeled toward veterinary education to prepare students better and to develop the expertise needed to meet this global security challenge.

Rational allocation of resources for educational programs—whether at the level of government agencies and foundations deciding where to direct grant funding or at the level of veterinary school administrators and educators deciding which particular technologies to employ—demands *evidence* that the investment will yield positive results. More specifically, for simulations in medical education, decision makers must see evidence that the use of such technology actually leads to desired and demonstrable learning outcomes. To address this issue, under the auspices of the Best Evidence Medical Education (BEME) Collaboration, we conducted and recently published a detailed, systematic review of the literature (spanning 34 years and 670 peer-reviewed journal articles).³² The BEME initiative^{35,36} is an internationally broad coalition of medical educators who are examining the evidence for the validity and effectiveness of various approaches to education that have been introduced during the last several decades and espoused with considerable vigor and enthusiasm, but for which a detailed and broad evaluation has not been accomplished. Based upon the principles that have been elaborated by the BEME group, in our study of the use of simulations in medical education, we identified ten features and uses of high-fidelity medical simulations that lead to effective learning:³²

- Feedback is provided during the learning experience.
- Learners engage in repetitive practice.
- The simulator is integrated into the medical curriculum.
- Learners practice with increasing levels of difficulty.

- The simulator is adaptable to multiple learning strategies.
- The simulator provides clinical variation.
- The simulator is embedded in a controlled environment.
- The simulator allows individualized learning.
- Outcome measures are expressed clearly.
- The simulator is a valid (high-fidelity) approximation to clinical practice.

Many of these features are consonant with Ericsson’s model of deliberate practice for achieving mastery in professional performance.^{15,16} We advise those who might wish to develop simulators for use in veterinary medical education to incorporate as many of these features as possible into their design and implementation plans; the end product of such an effort is more likely to be an effective educational tool.

CONCLUSION

Health professions education, particularly veterinary medical education today, faces many challenges in achieving the goal of producing competent practitioners. Multiple factors limit the opportunities for learners to practice the necessary professional and clinical skills with real patients. Simulations offer safe, ethical alternatives for training and provide opportunities for the deliberate practice that is so important to achieving mastery in professional performance. Currently, there are few animal simulators designed specifically for use in veterinary education but, just as in human medicine, new testing and accreditation requirements may spur the further development of such technologies. In addition, a growing concern for animal welfare and greater awareness of the need to train veterinarians to deal with modern threats such as bioterrorism may lead to increased funding for the development and implementation of simulation-based educational programs. Research has demonstrated the effectiveness of such instructional methods; simulation designers, veterinary school administrators, and educators should draw upon the best available evidence to match the features and uses of simulation technology to their training objectives. In this way, veterinary medical education can achieve its principal goal of graduating competent doctors with the skills needed to serve their profession, their patients, and the wider community.

NOTES

- a PHANTOM Devices, SensAble Technologies Inc., Woburn, MA <http://www.sensable.com/products/phantom_ghost/phantom.asp>.
- b Human Patient Simulator, Medical Education Technologies Inc., Sarasota, FL <<http://www.meti.com/hps.html>>.
- c Medical Education Technologies Inc., Sarasota, FL, as of 08/2005.

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