Humane Teaching Methods Demonstrate Efficacy in Veterinary Education

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Abstract

Animal use resulting in harm or death has historically played an integral role in veterinary education, in disciplines such as surgery, physiology, biochemistry, anatomy, pharmacology, and parasitology. However, many non-harmful alternatives now exist, including computer simulations, high quality videos, ‘ethically-sourced cadavers’ such as from animals euthanased for medical reasons, preserved specimens, models and surgical simulators, non-invasive self-experimentation and supervised clinical experiences. Prolonged struggles by veterinary students in Australia, the US and elsewhere have shown that many veterinary academics remain opposed to their introduction, usually citing concerns about teaching efficacy. Consequently, studies of veterinary students were reviewed comparing learning outcomes generated by non-harmful teaching methods with those achieved by harmful animal use. Of eleven published from 1989 to 2006, nine assessed surgical training—historically the discipline involving greatest harmful animal use. 45.5% (5/11) demonstrated superior learning outcomes using more humane alternatives. Another 45.5% (5/11) demonstrated equivalent learning outcomes and one (9.1%) demonstrated inferior learning outcomes. Twenty nine papers in which comparison with harmful animal use did not occur illustrated additional benefits of humane teaching methods, including: time and cost savings, enhanced potential for customisation and repeatability of the learning exercise, increased student confidence and satisfaction, increased compliance with animal use legislation, elimination of objections to the use of purpose-killed animals, and integration of clinical perspectives and ethics early in the curriculum. The evidence demonstrates that veterinary educators can best serve their students and animals, while minimising financial and time burdens, by introducing well-designed teaching methods not reliant on harmful animal use. However, due to their lack of support for the concept, too many Australian veterinary educators remain among the world’s worst teachers of humane veterinary surgical courses. Instead, they should aim to be among the best. Such an achievement is within their ability; it simply requires a fundamental change in attitude.

Keywords: alternative, animal experiment, education, training, veterinarian, veterinary surgery.
Introduction

Humane teaching methods in veterinary education

Animal use resulting in harm or death has historically played an integral role in veterinary education, in disciplines such as surgery, physiology, biochemistry, anatomy, pharmacology and parasitology. However, during the last two decades there has been a large increase in the availability of non-harmful alternatives, such as computer simulations, high quality videos, ‘ethically-sourced cadavers’ obtained from animals that have been euthanased for medical reasons, or that have died naturally or in accidents, preserved specimens, models and surgical simulators, non-invasive self-experimentation and supervised clinical experiences (Rowan 1991, Bauer 1993, Knight 1999, Gruber & Dewhurst 2004, Martinsen & Jukes 2006).

Humane veterinary surgical courses ideally comprise several stages. Students commence by learning basic manual skills such as suturing and instrument handling using knot-tying boards, plastic organs, and similar models. They then progress to simulated surgery on ethically-sourced cadavers. Finally students observe, assist with, and then perform necessary surgery under close supervision on real patients that actually benefit from the surgery—as distinct from on healthy animals that are later killed—similar to the manner in which physicians are trained (Knight 1999).

An important part of humane veterinary surgical courses worldwide are animal shelter sterilisation programs, in which homeless animals are neutered by students under supervision and returned to shelters. The popularity of these programs stems in part from the fact that all parties benefit from them. The animals have their adoption rates increased by neutering (Clevenger & Kass 2003), the numbers of unwanted animals subsequently killed due to uncontrolled breeding is decreased, the students gain invaluable experience at some of the most common procedures they will later perform in practice (Richardson et al. 1994, Howe & Slater 1997), and their veterinary school experiences the public relations benefits of providing a valued community service (Knight 1999).

Australian opposition to humane teaching methods

Despite their potential benefits, however, since at least 1986 to the present time (2006), it has been the experience of this author and veterinary student and faculty colleagues around the world that many veterinary academics remain opposed to the introduction of more humane teaching methods. As a veterinary student in 1998 at Western Australia’s Murdoch University Division of Veterinary & Biomedical Sciences, I was forced to initiate legal action and media exposure of curricular animal killing before Murdoch allowed me to use humane teaching methods. To its great credit, Murdoch then responded affirmatively by introducing Australia’s first formal policy allowing conscientious objection by students, agreeing to provide them with alternatives to harmful animal use during teaching or assessment activities on request. Similar policies have since been adopted by at least two other Australian (University of Sydney Faculty of Veterinary Science, University of Woollongong), and several US universities (e.g. the University of California (Berkeley), Cornell University, University of Illinois and Virginia Commonwealth University).

In 2000 a classmate and I became Western Australia’s first veterinary students to be granted alternatives to all of the fourth year terminal surgical laboratory classes (Knight 2001). We were effectively told that alternatives would be allowed, because the university was obliged by it conscientious objection policy to provide them. However, because certain academics did not agree with us, these alternatives would need to be self organised, and would take the form of practical instruction elsewhere, e.g. in private veterinary clinics and animal shelters. Additionally, we had to source our own animals, e.g. from shelters, and bring them back to the university to neuter them. We were also told that if we could not perform surgery or anaesthesia to the high standards of our academic examiners, they
would fail us. Additionally, we still had to attend all of the terminal surgical laboratories as observers.

There are many alternative veterinary surgical courses worldwide, but to my knowledge, this was the only such course in which the academics charged with providing practical instruction instead required that students arrange their own instruction elsewhere, and then required that they source their own animals to demonstrate their surgical abilities.

Despite these and other obstacles placed in our way, the alternative program we created proved an outstanding success. Jointly we refused to participate as surgeon or assistant surgeon in at most 13 terminal surgeries at Murdoch. However, we performed or assisted with at least 62 additional surgeries instead, not including the abdominal surgeries I performed on a ‘DASIE’ surgical simulator (Dog Abdominal Surrogate for Instructional Exercises—See Figure 1) I purchased from Canada. Quantitatively, we gained approximately five times the surgical and anaesthetic experience of our conventionally trained classmates. These surgeries were performed under supervision, mostly in private practice.

Our experiences had both depth and breadth—depth in the case of the large number of spays and castrations we performed, and breadth in that we also participated in a range of other surgeries as well. In total during 2000 we sterilised 45 dogs and cats.

The most important surgery for new graduates to be able to perform is the spay (female sterilisation). Although both positive and negative variation exists, most veterinary students worldwide and in Australia, perform, at best, only part of a single spay (which is often shared between two students), prior to graduation. Jointly we performed 21 spays before even beginning our final year. It felt exceedingly good to be contributing positively towards the dog and cat overpopulation problem by sterilising animals and thereby preventing unnecessary deaths, instead of causing them during our surgical training.

After another protracted period of negotiation lasting almost a year, I was able to convince our academics to provide two ethically-sourced canine cadavers obtained from animals euthanized for medical reasons, to allow us to perform five simulated abdominal, and two simulated orthopaedic surgeries, on them.

The result of this relatively high level of experience was that the skill and confidence deficiencies experienced by all new graduate veterinarians when beginning their surgical and clinical practice were substantially reduced in our case. To its considerable credit, Murdoch is presently seeking to establish an animal shelter sterilisation program that will similarly benefit all veterinary students, without compromising animal welfare or ethical standards.

Veterinary students at two of Australia’s three other established veterinary schools have experienced similar difficulties when seeking to use alternative teaching methods. The University of Sydney Faculty of Veterinary Science adopted very progressive policies with respect to humane alternatives in 2000 (elimination of all terminal surgical laboratories, implementation of a pound dog sterilisation program, adoption of a conscientious objection policy), but even there students still faced difficulties when requesting humane teaching methods as recently as 2003 (Anon. 2006a). Since 1999 this author has also corresponded with students struggling to overcome faculty opposition to requests for humane teaching methods at the University of Melbourne Faculty of Veterinary Science and the University of Queensland School of Veterinary Science. However, all of these students were ultimately successful, with the result that by 2005 the first students had graduated from all four established Australian veterinary schools without killing animals during their surgical training.
International opposition to humane teaching methods

Reports from veterinary students within the US and elsewhere indicate that although a growing number of veterinary schools worldwide have implemented humane teaching methods, to varying degrees, such opposition to their implementation remains common in veterinary schools around the world. Veterinary students requesting humane teaching methods have faced strong faculty opposition in at least the following veterinary schools:

- University of California (Davis) including the School of Veterinary Medicine: 1986-1992 (Rasmussen 1998);
- University of Florida College of Veterinary Medicine: 2000 (Pohost 2001);
- University of Illinois College of Veterinary Medicine: 1999–2000 (Stull 2003);
- Massey University Institute of Veterinary and Biomedical Sciences (New Zealand): 2001 (Beer 2002);
- Norwegian School of Veterinary Science: 1997–2002 (Martinsen 1998 & 2002);
- Ohio State University College of Veterinary Medicine: 1992 (Anon. 1997);
- Ontario Veterinary College, University of Guelph (Canada): 2002-2006 (Thompson 2003 and Papp 2006);
- Oregon State University College of Veterinary Medicine: 2000-2001 (McNamara 2001);
- Virginia-Maryland Regional College of Veterinary Medicine: 2001 (Chaves 2001); and,
- Washington State University College of Veterinary Medicine: 2002 (Anon. 2002);

Additionally, from 1998 to the present (2006) this author has corresponded with students facing faculty opposition to their requests for humane alternatives in at least another 10 veterinary schools, and at least 10 non-veterinary faculties, with the majority of those being located in the US.

Although not a definitive survey, these results nevertheless indicate that faculty opposition to student requests for humane teaching methods is an international, rather than an isolated problem, and that it is evident in some of the world’s leading veterinary schools.

On rare occasion, this opposition is described in veterinary journals. Fearon (2005), for example, describes an interview with Professor Kumar, head of veterinary gross anatomy at the Tufts University Cummings School of Veterinary Medicine in Massachusetts. Prof. Kumar established Tufts’ pet body donation program in 1995 (Kumar et al. 2001) to facilitate the sourcing of the cadavers of animals euthanased for medical reasons, as an ethical replacement to the use of purpose-killed animals in anatomy dissection and clinical skills training. Prof. Kumar described the opposition of almost all of his academic peers at other veterinary schools to student requests for the establishment of similar programmes as “arrogant,” and states that the general attitude to requests of this sort is that “you don’t let the inmates run the asylum.” (Fearon 2005).

In 2002 a ‘Petition for Rulemaking and Enforcement Under the Animal Welfare Act to Eliminate Violations of the Review of Alternatives Provisions’ was filed by the US Association of Veterinarians for Animal Rights and several veterinary students, with the United States Department of Agriculture, who have jurisdiction for enforcing this federal Act. All US veterinary schools were subsequently inspected, and nearly every school was cited for non-compliance with the Act. Most citations were issued for failing to search for alternatives to harmful or lethal animal use, or for failing to provide an adequate explanation as to why non-harmful alternatives were not being used. Many schools were also cited for duplicative use of animals and for the number of animals used, as well as for inappropriate species choice. Some were cited for lack of personnel training and animal identification, for conducting multiple potentially painful procedures, and for lack of information regarding anesthetics and methods used to kill animals (Anon 2005).
Such opposition to the use of humane teaching methods is not unique to veterinary educators. Non-veterinary students requesting humane teaching methods have similarly faced strong faculty opposition in at least the following institutions:

- University of Colorado School of Medicine: 1992-1995 (McCaffrey 1995);
- University of Frankfurt Faculty of Medicine: 1986–1990 (Völlm 1998);
- University of New Mexico in the Bachelor of Science (Biology) course: 1989-1991 (Hepner 2002);
- Portland Community College (Oregon) Science Department: 1997-1998 (Powell 1998);
- University of Santa Catarina, Biological Sciences (Brazil): 1998-1999 (Tréz 2002); and,
- University of Wales in the Bachelor of Science (Zoology) course: 1991 (Humphries 1998).

Again, this survey is not definitive, and it is likely that many additional institutions have also opposed student requests for humane teaching methods. Such opposition was demonstrated by the prestigious US National Association of Biology Teachers, which at first endorsed the use of humane alternatives in education, but which later rescinded this policy because of opposition from biology teachers. Commenting on this reversal, van der Valk et al. (1999) stated:

"Often, they are not interested in the ethics of using animals. Textbooks, laboratories and equipment are still oriented toward animal experimentation. Convincing these teachers of the advantages and ethics of using alternatives is difficult, the situation being very much polarised. Incorporating the principles of the Three Rs into teachers’ initial training and post-qualification professional development would help to overcome some of these difficulties."

There may be some interesting psychological phenomena underlying the resistance demonstrated by some faculty members to the use of humane teaching methods, including the need to personally justify the large-scale killing of animals for courses within their area of responsibility. Gruber & Dewhurst (2004) further assert that:

"Human vanity is also a factor that should not be underestimated. For many university teachers it is not acceptable to diverge from the methods one was taught and which one has always used in a life of teaching. Aversion towards accepting alternatives that were not developed in one’s own country also plays a role. Sometimes it appears that German, American and Japanese medicines are different entities."

Nevertheless, in the experiences of this author and veterinary and non-veterinary student colleagues worldwide, the reasons most commonly cited by faculty members opposed to the introduction of humane teaching methods are concerns about their educational efficacy. Given the prevalence of such concerns, reviews of relevant educational studies are warranted.

A review by Patronek & Rauch (2007) systematically reviewed learning outcomes achieved via humane teaching methods in comparison to those achieved by terminal live animal use. Seventeen studies were retrieved, of which five examined veterinary students, three examined medical students, six examined other undergraduate students and three examined high school biology students. For two of these studies of medical students, equivalent learning outcomes were achieved using alternatives to the dissection of human cadavers, and harmful animal use may not have occurred (Jones et al. 1978, Guy & Frisby 1992). Of the remaining 15 studies clearly involving comparisons with harmful animal use, four resulted in superior, and eleven resulted in equivalent learning outcomes, when humane teaching methods were used. Of the five veterinary student studies, two resulted in superior surgical skill acquisition when alternatives to terminal live animal use were employed, and three resulted in equivalent learning outcomes when alternatives to harmful
animal use were employed in surgical and physiology courses. Consequently, Patronek & Rauch concluded that “alternatives are a viable method of instruction in the field of biomedical education.” They encouraged “biomedical educators to consider how adopting alternative teaching methods could be of benefit to their teaching programs, students, and faculty members.”

By publishing one of the first such systematic reviews, Patronek & Rauch made a major contribution to this field. However, they only examined terminal live animal use, e.g., for animal dissection, live animal surgery and live animal physiology demonstrations. Other potentially harmful procedures, such as equine nasogastric intubation when conducted by novice practitioners, repetitive bovine rectal palpation, or even potentially stressful confinement and observation of non-domesticated species, were excluded from consideration. Additionally, only one bibliographic biomedical database (Pubmed) was searched for papers published from 1996 and 2004, and the search terms used were somewhat limited. Additional relevant comparative studies of student learning outcomes exist. Consequently I conducted a more comprehensive systematic review of student learning outcomes achieved via humane teaching methods in comparison to those achieved by harmful animal use.

**Materials and Methods**

The peer-reviewed biomedical literature was searched to locate studies of the learning outcomes achieved by veterinary students trained using non-harmful teaching methods, in comparison to those achieved by traditional harmful animal use. To ensure comprehensive coverage, the following six biomedical bibliographic databases were searched:

1. **CAB Abstracts**, which is the most comprehensive bibliographic database for the applied life sciences, covering veterinary medicine and many other disciplines. It contains over 4.5 million records from 1973 onwards, sourced from over 6,000 biomedical journals and more than 3,500 other documents from over 140 countries (Anon. undated a & b).

2. **The Cochrane Central Register of Controlled Trials (CENTRAL or CCTR)**, which is a bibliographic database of definitive controlled trials produced by the Cochrane Collaboration (www.cochrane.us) in co-operation with the National Library of Medicine in Washington, DC, who produce MEDLINE (see following), and Reed Elsevier of Amsterdam (the Netherlands), who produce EMBASE (see following). Over 350,000 bibliographic references to controlled trials in health care were included by 2003 (Anon. undated c).

3. **The Cochrane Database of Systematic Reviews (COCH)** is the main component of The Cochrane Library and includes regularly updated systematic reviews of the effects of healthcare prepared by The Cochrane Collaboration (Anon. undated c).

4. **The Cumulative Index to Nursing & Allied Health (CINAHL)** database, which provides authoritative coverage of the literature related to nursing and allied health. More than 1600 journals and many related documents are regularly indexed (Anon. undated d).

5. **EMBASE**, the Excerpta Medica database, which is a biomedical and pharmacological database containing over 10 million records from 1980 onwards covering veterinary medicine and many other disciplines, particularly those with relevance to pharmacology, sourced from over 3,500 biomedical journals (Anon. undated e).

6. **MEDLINE**, the United States National Library of Medicine’s premier bibliographic database, covering veterinary medicine and many other medical and related
disciplines. Medline contains over 12 million citations from 1966 onwards, sourced from more than 4,800 biomedical journals from over 70 countries (Anon. undated f).

All titles, abstracts, subject headings, and other key fields were searched for: ‘endoscopic simulation’ or ‘endoscopy simulation’ or ‘endoscopic simulator’ or ‘endoscopy simulator’ or ‘surgery simulator’ or ‘surgical simulator’ or ‘surgery simulation’ or ‘surgical simulation’ or ‘veterinary curriculum’ or ‘veterinary education’ or ‘veterinary student’ or ‘veterinary physiology’ or ‘veterinary surgery.’

These search terms were chosen partly because endoscopic simulators are a large and important sub-category within surgical simulators, and because both historically and contemporarily veterinary physiology and surgery remain the disciplines in which the greatest harmful use occurs, and consequently the greatest efforts to replace such use with humane alternatives have also occurred in these disciplines.

The abstracts, and, occasionally, complete papers, were examined to locate studies of veterinary and non-veterinary student performance achieved using humane alternatives in comparison to harmful animal use. Cited references of retrieved papers were also reviewed to identify additional relevant papers.

Additionally, the main reference books within this field were searched (Balcombe 2000b, Knight 2002, Jukes & Chiua 2003).

For the purposes of this review, animal use considered harmful included:

- invasive procedures, or those reasonably likely to be significantly stressful, such as:
  - equine nasogastric intubation (when conducted by novice practitioners);
  - most physiology, pharmacology and biochemistry demonstration laboratories using live animal subjects or living tissue from recently killed animals;
  - surgical procedures other than those described below; and,
- any use of animals resulting in death, other than genuine euthanasia performed solely for medical or severe and intractable behavioural reasons; and,
- the dissection of purpose killed animals.

Animal use considered non-harmful included:

- observation of wild, feral or companion animals in field studies;
- minimally-invasive or stressful procedures conducted on living animals, such as bovine rectal palpation (although repeated use in some veterinary practical classes can become stressful and/or harmful);
- invasive procedures conducted for the benefit of genuine animal patients, such as neutering operations and similarly beneficial elective surgeries performed on healthy animals, and emergency surgeries conducted on injured or unwell animals; and,
- dissection, clinical or surgical procedures performed on cadavers obtained from animals that had been euthanased for medical reasons, or had died naturally or in accidents (ethically-sourced cadavers, including the cadavers of humans donated for use in medical education).

With respect to studies of veterinary surgical training, in which surgery performed on living animals was compared with that conducted on cadavers or inanimate models, the source of the cadavers was unspecified in most studies. However, cadavers are usually obtained from ethically-questionable sources, such as the greyhound racing industry and animal control agencies (‘pounds’). Consequently, when compared with a non-animal alternative (e.g.,
Griffon et al. 2000), the latter was considered the more ‘humane’ option for the purposes of this review.

However, cadavers may also be ethically-sourced, and a minority of veterinary schools, including at least nine in the US (the University of California (Davis) School of Veterinary Medicine (SVM), University of Minnesota College of Veterinary Medicine (CVM), Mississippi State University CVM, University of Missouri-Columbia CVM, University of Pennsylvania SVM, Texas A&M CVM, Tufts University Cummings SVM, Western University of Health Sciences CVM and the University of Wisconsin (Madison) SVM (Donley & Stull 2001, McCoy 2003, Anon. 2006b, Duda 2006), have established client donation programs in their teaching hospitals, to facilitate the use for teaching purposes of cadavers from animals euthanased for medical reasons. Since 1998 similar programs have been established at Australian veterinary schools at Melbourne University, Murdoch University and the University of Sydney; however, by 2006 senior veterinary students interested in using humane alternatives at the latter two schools were unaware of the availability of any ethically-sourced cadavers, indicating that these two programmes were probably inactive.

Nevertheless, given their potential for ethical-sourcing when compared with ‘terminal’ (lethal) live animal use (the norm in veterinary surgical training), a cadaver was considered to be the more ‘humane’ option.

Results
Biomedical bibliographic databases are constantly updated. As of 22 Dec. 2006, 3,954 records were located using the specified search terms. These were examined to identify studies of veterinary and non-veterinary student learning outcomes comparing harmful animal use with humane teaching methods.
Increasing numbers of veterinary schools around the world have introduced non-harmful teaching methods, which have sometimes been accompanied by educational evaluations. Twelve papers published from 1989 to 2006 described studies of veterinary students comparing learning outcomes generated by humane alternatives with those achieved by traditional harmful animal use (Table 1).

Greenfield et al. (1994 & 1995) described the same study; hence 11 distinct studies of veterinary student learning outcomes were retrieved. Nine of these veterinary student studies assessed surgical training—historically the area of greatest harmful animal use.

In 45.5% (5/11) of cases, superior learning outcomes (superior skill or knowledge, or equivalent performance with reduced activity times) resulted from the use of the
humane option; equivalent learning outcomes also resulted in 45.5% (5/11) of cases; and in one case (9.1%) the humane option resulted in inferior learning outcomes.

Twenty one papers published from 1968 to 2004 described studies of non-veterinary students in related academic disciplines, similarly comparing learning outcomes generated by humane alternatives with those achieved by traditional harmful animal use (Table 2).

<table>
<thead>
<tr>
<th>Study</th>
<th>Discipline</th>
<th>Humane option</th>
<th>Equivalent learning outcomes</th>
<th>Equal or superior</th>
<th>Inferior learning outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cohen &amp; Block 1991</td>
<td>psychology</td>
<td>field study (feral pigeons)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clark 1987</td>
<td>physiology</td>
<td>computer simulation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cross &amp; Cross 2004</td>
<td>biology (high school)</td>
<td>computer simulation</td>
<td>74 (38)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dewhurst et al. 1988</td>
<td>physiology</td>
<td>computer simulation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dewhurst &amp; Meehan 1993</td>
<td>physiology, pharmacology</td>
<td>computer simulations</td>
<td>65</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dewhurst et al. 1994</td>
<td>physiology</td>
<td>computer simulation</td>
<td>14 (6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Downie &amp; Meadows 1995</td>
<td>biology (undergraduate)</td>
<td>models (rats)</td>
<td>2913 (308)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fowler &amp; Brosius 1968</td>
<td>biology (high school)</td>
<td>video</td>
<td>156</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Henman &amp; Leach 1983</td>
<td>pharmacology</td>
<td>biovideograph videotape recordings</td>
<td>50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hughes 2001</td>
<td>pharmacology</td>
<td>computer simulations</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kinzie et al. 1993</td>
<td>biology (high school)</td>
<td>interactive videodisc</td>
<td>61</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leathard &amp; Dewhurst 1995</td>
<td>physiology (medicine)</td>
<td>computer simulation</td>
<td>156</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leonard 1992</td>
<td>biology (undergraduate)</td>
<td>interactive videodisc</td>
<td>142</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lieb 1985</td>
<td>biology (high school)</td>
<td>lecture</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Matthews 1998</td>
<td>biology (undergraduate)</td>
<td>computer simulation</td>
<td>20 (12)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The papers by Dewhurst et al. (1993 & 1994) may have described the same study; hence at least twenty distinct studies of non-veterinary student learning outcomes were retrieved.

Seven of these studies of related non-veterinary disciplines examined high school biology students, while 13 examined undergraduate biology, medical, nursing, pharmacology, physiology and psychology students. The seven studies of high school biology students published from 1968 to 2004 examined anatomical knowledge using alternatives to the dissection of purpose killed animals. Three studies demonstrated superior, three studies demonstrated equivalent, and one study demonstrated inferior knowledge acquisition, when humane alternatives were used.

Of the 13 studies examining undergraduate students published from 1983 to 2001, 38.5% (5/13) demonstrated that alternative students achieved superior learning outcomes, or achieved equivalent results more quickly, allowing time for additional learning. 53.8% percent (7/13) demonstrated equivalent educational efficacy, and only one study (7.7%) demonstrated inferior educational efficacy of humane alternatives.

Twenty nine papers published from 1983 to 2006 not involving comparisons with harmful animal use were also identified, illustrating additional benefits of humane teaching methods when used veterinary in education (Table 3).
Table 3: Additional benefits of humane teaching methods in veterinary education

<table>
<thead>
<tr>
<th>Study</th>
<th>Veterinary discipline</th>
<th>Humane option</th>
<th>Benefits of humane option (besides decreased harmful animal use)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allen &amp; Hambers 1999</td>
<td>surgery</td>
<td>puterised tutorials</td>
<td>increased surgical skill</td>
</tr>
<tr>
<td>Baillie et al. 2003</td>
<td>clinical skills (bovine)</td>
<td>virtual reality simulator</td>
<td>customization of learning experience, repeatability, superior skill acquisition and development</td>
</tr>
<tr>
<td>Baillie et al. 2005a</td>
<td>clinical skills (bovine)</td>
<td>virtual reality simulator</td>
<td>customization of learning experience, repeatability, superior skill acquisition and development</td>
</tr>
<tr>
<td>Baillie et al. 2005b</td>
<td>clinical skills (bovine)</td>
<td>virtual reality simulator</td>
<td>customization of learning experience, repeatability, superior skill acquisition and development</td>
</tr>
<tr>
<td>Buchanan et al. 2005</td>
<td>biochemistry</td>
<td>3D animations</td>
<td>superior understanding of complex biological processes</td>
</tr>
<tr>
<td>Dhein &amp; Memon 2003</td>
<td>Continuing education</td>
<td>internet based curriculum</td>
<td>overcomes obstacles of time and distance, decreased costs, facilitates lifelong learning</td>
</tr>
<tr>
<td>Dyson 2003</td>
<td>anaesthesia</td>
<td>CD-ROM</td>
<td>increased anaesthetic knowledge</td>
</tr>
<tr>
<td>Ellaway et al. 2005</td>
<td>unspecified</td>
<td>virtual learning environment</td>
<td>increased flexibility of use</td>
</tr>
<tr>
<td>Erickson &amp; Clegg 1993</td>
<td>physiology</td>
<td>puter simulation</td>
<td>greatest student satisfaction</td>
</tr>
<tr>
<td>Galle U &amp; Bubna-Littitz 1983</td>
<td>clinical skills (canine)</td>
<td>cadaver</td>
<td>repeatability</td>
</tr>
<tr>
<td>Greenfield et al. 1994</td>
<td>surgery</td>
<td>models</td>
<td>decreased student and faculty objections to harmful animal use</td>
</tr>
<tr>
<td>Hawkins et al. 2003</td>
<td>clinical skills (small animal)</td>
<td>video</td>
<td>increased diagnostic skills</td>
</tr>
<tr>
<td>Hines et al. 2005</td>
<td>pathology</td>
<td>virtual learning environment</td>
<td>greater understanding, student satisfaction, increased flexibility of use</td>
</tr>
<tr>
<td>Holmberg et al. 1993</td>
<td>surgery</td>
<td>model</td>
<td>decreased student stress, repeatability</td>
</tr>
<tr>
<td>Howe &amp; Slater 1997</td>
<td>surgery</td>
<td>simulation progr</td>
<td>increased surgical and anaesthetic skills including atraumatic tissue handling, increased understanding of the pet overpopulation problem and the role of the veterinarian in combating it, increased awareness of the activities of humane organisations</td>
</tr>
<tr>
<td>Howe et al. 2005</td>
<td>surgery</td>
<td>CD-ROM</td>
<td>increased practice of techniques, enhanced preparedness for laboratories, greater student satisfaction</td>
</tr>
<tr>
<td>Josephon &amp; Moore 2006</td>
<td>anatomy</td>
<td>DVD</td>
<td>customisation of learning experience to individual needs, possibly increased examination results</td>
</tr>
<tr>
<td>Authors</td>
<td>Year</td>
<td>Field</td>
<td>Type</td>
</tr>
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<tr>
<td>Martínez et al.</td>
<td>2020</td>
<td>anatomy</td>
<td>cadavers</td>
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<tr>
<td>Taron et al.</td>
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<td>Hearn et al.</td>
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Nb: ‘Hypermedia’ refers to interactive information media in which graphics, audio, video, plain text and hyperlinks intertwine in a structure that is generally non-linear. In contrast, the broader term ‘multimedia’ may also be used to describe non-interactive linear presentations reliant on a variety of media, as well as hypermedia (Nelson 1965).

**Discussion**

**Efficacy of humane teaching methods in comparison to harmful animal use**

**Veterinary surgical training**

Skills assessed in surgical laboratories included psychomotor (all), ligation (Griffon et al. 2000 and Olsen et al. 1996), intestinal anastomoses and celiotomy closures (Carpenter et al. 1991), gastrotomy closures (Smeeak et al. 1994) and ovariohysterectomies (Griffon et al. 2000).

Overall, the surgical skills generated by these humane alternatives were at least equivalent to those achieved via traditional harmful animal use. Three surgical studies demonstrated superior surgical skills when humane alternatives were used. Johnson & Farmer (1989) found that inanimate models were superior to live animals in teaching basic psychomotor skills. Olsen et al. (1996) demonstrated that a fluid haemostasis model was at least as effective as a live dog splenectomy for teaching blood vessel ligation and division. In fact, students using the model completed their ligatures more quickly, with fewer errors. They successfully tied more square knots, their ligatures were tighter, and their instrument grip was superior. These students’ initial scepticism regarding the use of properly designed inanimate models for teaching these surgical skills was dramatically altered. Griffon et al. (2000) found that 20 veterinary surgical students trained using plastic surgical simulators performed ovariohysterectomies on live dogs with greater skill than 20 classmates trained via cadavers. In all cases the ability to use the models repeatedly contributed to the superior surgical skills of the students who used them.

Five studies demonstrated equivalent surgical skills when humane alternatives were compared to harmful animal use (Carpenter et al. 1991, Bauer et al. 1992, White et al. 1992, Pavletic et al. 1994, Greenfield et al. 1994 & 1995). Carpenter et al. (1991) and Bauer et al. (1992) demonstrated equivalent surgical skill acquisition using cadavers as the humane option, while Greenfield et al. (1994 & 1995) demonstrated a similar result using soft tissue organ models. White et al. (1992) found that veterinary students from an alternative surgical laboratory program had surgical skills equivalent to those with a standard laboratory experience, after some initial hesitancy in the alternative students during their first live animal surgery.

One study demonstrated inferior surgical skill acquisition using the humane option. Smeeak et al. (1994) compared live animal gastrotomy skills of two groups of 20 students, one of which had practiced the procedure using a hollow organ model, and the other of which had practiced using a live animal. While they found no significant difference in overall gastrotomy closure technique, the students performing the procedure for a second time on a live animal were significantly quicker. Anaesthetic time is an important surgical consideration; hence this was considered a superior learning outcome. However, the plastic model used in this study was deficient, being more fragile and stiff than living gastric tissue, with suture pull-through occurring despite appropriate technique and tension; even though the model was found to be effective for teaching instrument use, needle placement, atraumatic tissue handling and tissue inversion.

Learning outcomes were compared both in the short-term (Johnson & Farmer 1989, Carpenter et al. 1991, Bauer et al. 1992, White et al. 1992, Smeeak et al. 1994, Greenfield et al. 1994 & 1995, Olsen et al. 1996 and Griffon et al. 2000), and long term. Pavletic et al. (1994) studied new graduates from the Tufts University veterinary class of 1990, which included 12 students who had participated in an alternative small animal medical and surgical procedures course. This involved the use of ethically-sourced cadavers and additional clinical rotations in small animal surgery (4 weeks), small animal medicine (1 week) and intensive care (1 week). These students and 36 of their conventionally trained peers were assessed by questionnaires sent to their employers, who were asked to rate their competency at the time of hiring and 12 months later. There was no significant difference on either occasion in the abilities of the conventional and alternative graduates when performing common surgical, medical and diagnostic procedures, in their attitudes towards performing orthopaedic
or soft tissue surgery, confidence in performing the listed procedures, or ability to perform them unassisted.

The success of humane surgical training has also been reported for UK veterinary graduates. The UK is the only major region of the developed world where harmful animal use has been removed from the veterinary surgical curriculum for decades; instead students gain practical experience by assisting with beneficial surgeries during extramural studies at private veterinary clinics. In 1998 Fitzpatrick & Mellor (2003) surveyed graduates from all veterinary schools in Great Britain and Ireland who had graduated within the previous five years. Ninety-five per cent of respondents were working full time in veterinary practice. Graduates rated extramural studies as “very useful” for three subjects, two of which were small animal surgery and cattle surgery.

**Veterinary disciplines other than surgery**

Both historically and contemporarily, surgery and physiology respectively are the disciplines that have resulted in the greatest harmful animal use during veterinary education. Disciplines other than surgery were poorly represented in comparative studies of veterinary student performance, totalling only two studies.

Abutarbush et al. (2006) found that a CD-ROM was more effective than a live animal demonstration by an instructor of the correct method for inserting a nasogastric tube into a horse. Students using the CD-ROM performed significantly better on a test of knowledge, were more confident, and were significantly quicker at successfully inserting a nasogastric tube into a live horse, than their traditionally instructed peers.

Fawver et al. (1990) found that first year veterinary students learnt cardiovascular physiology principles more efficiently from interactive videodisc simulations than from live animal laboratories, resulting in both student and staff time savings.

**Related non-veterinary disciplines**

Thirteen studies examined learning outcomes of undergraduate biology, medical, nursing, pharmacology, physiology and psychology students. A very slightly higher proportion of non-veterinary students achieved superior or equivalent learning outcomes using humane alternatives, when compared to veterinary students.

Cardiovascular physiology students achieved equivalent learning outcomes using computer simulations (Clarke 1987 and Dewhurst et al. 1988), and superior learning outcomes using an interactive video program (nursing students, Phelps et al. 1992), compared to animal based laboratories, and rated computer simulations as superior for learning (medical students, Samsel et al. 1994). Intestinal physiology students working independently with a computer program gained equal knowledge, at one-fifth the cost, compared to students using freshly killed rats (Dewhurst et al. 1994 and Leathard & Dewhurst 1995). Physiology and pharmacology students using computer simulations performed as well as students using traditional animal laboratories (Dewhurst & Meehan 1993). Pharmacology students achieved superior learning outcomes using biovideogaph videotapes (Henman & Leach 1983) and equivalent learning outcomes overall (superior initially in each of five experiments but possibly with inferior long-term recall of experimental details) using computer simulations (Hughes 2001), in comparison to outcomes achieved via animal based laboratories. Biology students achieved superior (computer simulations, More & Ralph 1992) or equivalent (videodisc, Leonard 1992; models, Downie & Meadows 1995) learning outcomes using alternatives to dissections. Additionally, the videodisc group used only half the time required by the traditional laboratory group.
Only one study of non-veterinary students demonstrated inferior learning outcomes when the humane teaching option was used. Eight undergraduate biology students who dissected foetal pigs scored significantly higher on an oral test with prospected foetal pigs than twelve students who studied using a computer simulation (‘MacPig,’ Matthews 1998). However, MacPig is considered to be insufficiently detailed for college level biology instruction (Balcombe 1998).

**Impact of chronology on comparative studies**

Of the 12 papers comparing veterinary student learning outcomes, nine were more than a decade old (published prior to 1996). Of the 21 papers describing non-veterinary student learning outcomes, 18 were more than a decade old. Hence, a considerable number of these studies examined humane teaching methods such as films, interactive video discs, and early computer simulations, which have been largely superseded by more advanced alternatives, particularly in the field of computer simulations. The laboratories these alternatives were designed to replace, such as animal dissections and live animal experimental or surgical laboratories, have, on the other hand, remained largely unaltered. It is a damning indictment of harmful animal use that even such relatively antiquated alternatives almost always resulted in superior or equivalent learning outcomes. It is likely that comparative studies of modern alternative teaching methods would yield an even higher proportion of studies demonstrating superior learning outcomes when these are used.

**Animal welfare benefits and improved legislative compliance**

Advantages of humane alternatives other than educational efficacy include the saving of substantial numbers of animal lives. Few countries record the numbers of animals used for educational purposes, and of those that do, most consider only live vertebrate use, and fail to include invertebrates or vertebrates killed for dissections. Additionally, the small minority of non-harmful use is rarely, if ever, differentiated from overall animal use. Consequently, the numbers of animals harmed for educational purposes are difficult to ascertain. Nevertheless, it is clear that those numbers are substantial. It was estimated that approximately nine million vertebrate animals and a similar number of invertebrates were used in biomedical education in the United States in 2000 (Balcombe 2000b). From 1985 to 1996, the Canadian Council on Animal Care estimated that around 85,000 living vertebrates and some ‘higher’ invertebrates such as cephalopods were used annually in university teaching (Balcombe 2000a). The total number of animals used in Australian teaching is unclear, but in just four states that kept partial statistics (New South Wales, South Australia, Tasmania and Victoria) the recorded use was in excess of 100,000 annually, around 1996 (Office of Animal Welfare 1996; Animal Research Review Panel New South Wales 1997; Bureau of Animal Welfare, Agriculture & Resources 1997 and Public Health & Animal Welfare Section 1997).

Apart from directly saving large numbers of animal lives, humane teaching methods also facilitate increased compliance with legislative and Code of Practice requirements restricting educational or other scientific animal use, which exist in a large number of countries (Balcombe 2000a). In Australia, for example, the Australian Code of Practice for the Care and Use of Animals for Scientific Purposes, which is legally enforceable in every state and territory, requires alternatives to the use of animals wherever possible for educational and other scientific purposes (NHMRC 2004).

The already considerable importance of these factors is expected to increase as society becomes ever more conscious of the importance of animal welfare (Siegford et al. 2005), and consequently, less willing to permit harmful animal use for educational purposes (Scalese & Issenberg 2005).
Additionally, as stated previously, where veterinary students participate in animal shelter sterilisation programs, uncontrolled companion animal breeding is decreased and adoption rates are increased, directly and positively impacting on animal welfare (Clevenger & Kass 2003).

Finally, there is evidence to suggest that veterinary education may result in the decreased likeliness of students to view animals as sentient, a decreased empathy towards animals, a decreased propensity to administer peri-operative analgesics, and the impedance of normal development of moral reasoning ability (Self et al. 1991 & 1996, Hellyer et al. 1999, Paul & Podberscek 2000 and Levine et al. 2005). Along with inadequate curricular attention to animal welfare science, the human-animal bond and the development of critical reasoning ability and ethics (Self et al. 1994 and Williams et al. 1999), the harmful use of animals during veterinary education is a likely cause of such phenomena (De Boo & Knight 2005 & 2006). The apparent reduction in concern for animal welfare may, in some cases, represent psychological adaptations enabling veterinary students to withstand what could otherwise be intolerable psychological stresses resulting from curricular requirements to harm sentient creatures in the absence of overwhelming necessity (Capaldo 2004). Consequently, the replacement of harmful animal use with humane teaching methods is likely to result in veterinarians with more positive attitudes towards animal welfare, which is likely to directly benefit their animal patients.

**Additional advantages of humane teaching methods**

**Veterinary disciplines**

Twenty nine papers describing humane teaching methods in veterinary education that did not involve comparisons with harmful animal use (although comparison with non-harmful teaching methods did sometimes occur) illustrated other advantages of these methods (Table 3). These included:

- customization of the learning experience (e.g. ability to work at own pace and explore areas of deficient understanding) and repeatability of the learning exercise (Galle & Bubna-Littitz 1983, Simpson & Meuten 1992, Holmberg et al. 1993, Whithear et al. 1994, Baillie et al. 2003 & 2005a-b, Dhein & Memon 2003, Howe et al. 2005 and Josephon & Moore 2006), and increased flexibility of use (Dhein & Memon 2003, Ellaway et al. 2005 and Hines et al. 2005);


- superior understanding of complex biological processes (specifically, interactions between intracellular molecules and their spatial relationships within cells, Buchanan et al. 2005), and of systemic pathology (Hines et al. 2005), rapid access to relevant anatomical views such as radiographs, and increased learning efficiency (Linton et al. 2005);

- enhanced preparedness for laboratories (Howe et al. 2005), and, on occasion, increased realism of the laboratory experience (Modell et al. 2002);

- increased examination results (parasitology, Pinkney et al. 2001; anaesthesiology, Modell et al. 2002 and anatomy, Josephon & Moore 2006);

et al. 2005), including when coping with complex clinical problems (Modell et al. 2002);

- enhanced student information retrieval and communication abilities, improved student attitudes towards computers, and increased employer perception of computer literacy (Waldhalm & Bushby 1996);

- facilitation of ongoing undergraduate and postgraduate learning (Whithear et al. 1994, Dhein & Memon 2003);

- increased teaching efficiency and decreased costs (Rudas et al. 1993, Dhein & Memon 2003);

- increased compliance with animal use regulations, elimination of student and faculty objections to the use of purpose-killed animals, and integration of clinical perspectives and ethics early in the curriculum (Greenfield et al. 1994, Kumar et al. 2001); and,

- increased understanding of the pet overpopulation problem and the role of the veterinarian in combating it, and increased awareness of the activities of humane organisations, when veterinary students participate in animal shelter sterilization programs (Richardson et al. 1994, Howe & Slater 1997).

Unusually, one alternative teaching model, the ‘Bovine Rectal Palpation Simulator,’ was described in three of these papers (Baillie et al. 2003 & 2005a-b). Bovine rectal palpation is most commonly conducted for the purposes of pregnancy diagnosis. Designed to teach the necessary skills via a haptic system, this model applies anatomically appropriate tension to a student’s fingers depending on their spatial location inside a simulated cow. Haptic technology simulates the tactile feedback that would be experienced when manipulating real tissue, and is an important component of many virtual reality simulators.

Baillie et al. found that students using the simulator were able to customise their learning experiences according to individual need, and that they performed better when examining real cows for the first time than their traditionally trained peers. However, bovine rectal palpation is not normally harmful or particularly stressful unless performed repeatedly. Hence this animal use was not considered harmful for the purposes of this review, although some repeated use does occur in veterinary practical classes.

**Related non-veterinary disciplines**

Numerous papers describing related non-veterinary disciplines not involving comparisons with harmful animal use (although comparison with non-harmful teaching methods did sometimes occur) have illustrated additional advantages, and very occasionally, disadvantages, of humane teaching methods. Over 500 such papers published from 1974 to 2006 were identified by this review. Many of these described the development, validation, and effects on surgical planning, skill levels and other surgical or educational outcomes of the use of endoscopic other surgical simulators. Validation refers to the ability of a simulator to accurately predict real surgical skill levels, and is typically achieved when experienced and inexperienced surgeons demonstrate differing skill levels while using the simulator.

A rigorous analysis of these papers is beyond the scope of this review. However, examples of papers of particular interest to veterinary educators include:

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- three papers indicating equivalent learning outcomes when alternatives to the dissection of human cadavers (prosected specimens, a stereoscopic slide based auto-instructional program, interactive videodiscs and computer simulations) were used (medical students, Prentice et al. 1977 and Jones et al. 1978; human gross anatomy, pre-nursing and allied medical profession students, Guy & Frisby 1992);

- a paper by Szinicz et al. (1997) describing the use of the pulsatile organ perfusion ('POP trainer'), in which arteries in waste organs (commonly, from slaughterhouses, although ethically-sourced cadavers could also be used), are perfused with an artificial blood solution connected to a pulsatile pump, for training in both minimally invasive and conventional surgical techniques. Unlike many surgical simulators, this model allows practice of haemostatic techniques. Even complex operations, such as colorectal and antireflux procedures may be performed;

- two papers discussing the potential for globalised surgical teaching via telesurgery: the introduction of miniaturised cameras into patients during surgery (Marescaux et al. 1999a & 1999b);

- a paper by Kunzel & Dier (2001) described the development of a realistic intubation simulator for practicing endotracheal intubation in dogs. A study by Hall et al. (2005) demonstrated that the human intubation skills of paramedical students who were trained using a simulator were equivalent to those trained on human subjects;

- a study by Huang & Aloia (1991), which demonstrated the improved learning outcomes of undergraduate biology students who used computer simulations of dissections. Similarly, Holt et al. (2001) demonstrated that computer assisted learning can be effective at teaching endocrinology to medical students;

- one study demonstrated increased student satisfaction and examination results for cardiovascular physiology students when computer simulations were used (Lilienfield & Broering 1994), while another demonstrated cardiovascular physiology knowledge acquisition equivalent to that gained from a textbook, although these medical students rated the computer simulation superior for reinforcement and review (Specht 1988); and,

- Dewhurst & Jenkinson (1995) demonstrated that computer simulations generally saved teaching staff time, were less expensive, and were an effective and enjoyable mode of undergraduate biomedical student learning.

A very small minority of studies overall demonstrated inferior learning outcomes when humane teaching methods were used. For example, Rogers et al. (1998) demonstrated lesser basic surgical skill acquisition (the ability to correctly tie a square knot) acquired by medical students when a CAL program was used instead of a lecture and feedback seminar. Student comments suggested that the lack of feedback in this CAL model resulted in the significant difference between these two learning outcomes. Caversaccio et al. (2003) found that a virtual simulator enhanced understanding of endonasal surgery but failed to make an impact on operating room performance. The simulator's effectiveness was limited by the absence of force feedback, subtle handling of the joysticks, and considerable time consumption. Gerson & Van Dam (2004) found
that medical residents trained to perform a sigmoidoscopy via traditional bedside teaching techniques achieved greater skill than those trained using an endoscopy simulator. Furthermore, a review of 30 randomized controlled trials assessing any training technique using at least some elements of surgical simulation found that none of the methods of simulated training (computer simulation, models, cadavers) were conclusively superior to one another or to standard surgical training, primarily of medical students and practitioners (Sutherland et al. 2006). These studies emphasise the importance of ensuring that humane teaching methods are well designed and are focused on achieving the specific learning outcomes desired.

**Student concerns**

Two key advantages of humane alternatives relate to students. The highly toxic chemicals used to preserve anatomy specimens between dissections present health hazards, incurring the potential for legal and financial liability should students suffer exposure-related adverse health effects. In the experience of this author and his veterinary student colleagues from 1998-2006, recommended safety guidelines such as the use of gloves, gowns and masks are not commonly met with full compliance in veterinary schools. Examples include the Murdoch University Division of Veterinary & Biomedical Sciences, 1998 (personal experience); the University of Sydney Faculty of Veterinary Science, 2003 (Anon. 2006); and the Ontario Veterinary College, University of Guelph (Canada), 2004-2006 (Papp 2006). These veterinary schools all had high standards, and once again this very limited survey suggests that there may be a wider problem internationally, rather than indicating a unique problem with these specific schools.

Additionally, faculty opposition to strong student desires for humane teaching methods frequently result in conflict. A substantial number of countries have banned the harmful use of animals in primary and secondary school (mostly) or university education, outright. In a smaller group, including England, Germany, Italy, India, The Netherlands and the US, the rights of students to educational methods that do not violate their conscientiously held ethical or religious beliefs against harming animals are protected by various constitutional safeguards, legislation, policies or conventions, which have contributed to several successful lawsuits by students (Francione & Charlton 1992, Balcombe 2000a and 2000b). Examples include the University of Frankfurt Faculty of Medicine, 1988-1991 (Völlm 1998); the Ohio State University College of Veterinary Medicine, 1992 (Anon. 1997); the University of Santa Catarina, Biological Sciences (Brazil), 1998-1999 (Tréz 2002); and the University of Colorado School of Medicine, 1993 – 1995 (McCaffrey 1995). In the latter case, besides being required to introduce humane teaching methods, USD 95,000 in damages and costs was awarded against the University of Colorado in 1995.

**Conclusions**

Sufficient studies have been conducted to draw some conclusions about the efficacy of humane teaching methods in imparting surgical skills or knowledge. Well-designed humane alternatives generally perform at least as well as methods that rely upon harmful animal use, in some cases achieving superior learning outcomes. These have included superior surgical, anaesthetic and other clinical skill acquisition and development, superior understanding of complex biological processes, increased learning efficiency, and increased examination results. Additionally, increased teaching efficiency and decreased costs, along with enhanced potential for customisation and repeatability of the learning exercise, frequently result from the use of humane teaching methods. Increased student confidence and satisfaction, enhanced preparedness for laboratories and decreased student stress may also occur, as may enhanced student information retrieval and communication abilities, improved student attitudes towards computers, and increased employer perception of computer literacy.
Increased compliance with animal use legislation or regulations, elimination of student and faculty objections to the use of purpose-killed animals, and integration of clinical perspectives and ethics early in the curriculum all result from the use of humane teaching methods. Substantial numbers of animal lives are saved, and some evidence also suggests veterinarians trained without harmful animal use may develop higher animal welfare standards, potentially benefitting their future patients. They may even gain increased understanding of the pet overpopulation problem and the role of the veterinarian in combating it.

Rather than continuing to rely upon harmful animal use, the evidence clearly indicates that veterinary educators can best serve their students and animals, and can minimise financial and time burdens upon their faculties, by introducing modern, humane teaching methodologies.

However, with the noteworthy exception of the program at the University of Sydney Faculty of Veterinary Science, existing Australian alternative veterinary surgical programs remain among the worst in the world. Nowhere else are humane veterinary surgical courses so poorly supported that veterinary students are required to arrange their own practical instruction outside the veterinary school, and then required to source their own animal subjects for conducting elective surgeries within the veterinary school for assessment purposes.

Instead of being content with maintaining our dubious status among the world’s worst instructors of humane veterinary surgical courses, it is time we Australians started aiming to be among the best. Such an achievement is within our ability; it simply requires a fundamental change in attitude.

Detailed information about the alternatives available for various academic disciplines is provided by Jukes & Chiuia (2003) and by web sites such as www.vetmed.ucdavis.edu/Animal_Alternatives and www.clive.ed.ac.uk. Synopses of surgical simulators designed for medical students and practitioners are provided at www.virtualsurgery.vision.ee.ethz.ch. Comprehensive alternatives databases, alternatives lending libraries, reviews of leading alternatives, free on-line computer simulations, and hundreds of educational studies of alternatives organised by academic discipline are also available at web sites such as www.HumaneLearning.info and www.EURCA.org.

References

Humane Teaching Methods Demonstrate Efficacy in Veterinary Education

http://www.veterinaria.org/revistas/redvet/n101008B/BA049.pdf
Humane Teaching Methods Demonstrate Efficacy in Veterinary Education


Capaldo T. The psychological effects on students of using animals in ways that they see as ethically, morally or religiously wrong. Altern Lab Anim 2004;32(Suppl 1b):525–31.


Chaves C. Facing and dealing with ethical dilemmas in veterinary education. Alternatives in Veterinary Medical Education 2001;17:2-3.


Duda L. Personal communication to Andrew Knight re: the University of Pennsylvania School of Veterinary Medicine client donation program for ethical cadaver sourcing, which she helped establish. 2006.

Dyson DH. Non-linear, visual-rich supplemental material designed for an introductory course in veterinary anaesthesia. *Journal of Veterinary Medical Education* 2003;30(4):360-3.


• Guy JF & Frisby AJ. Using interactive videodiscs to teach gross anatomy to undergraduates at Ohio State University. _Academic Medicine_ 1992;67:132-3.
• Henman MC & Leach GDH. An alternative method for pharmacology laboratory class instruction using biovideograph videotape recordings. _British Journal of Pharmacology_ 1983;80:591P.
• Holt RI, Miklaszewicz P, Cranston IC, Russell-Jones D, Rees PJ & Sonksen PH. Computer assisted learning is an effective way of teaching endocrinology. _Clin Endocrinol (Oxf)_ 2001;55(4):537-42.


• Knight A. Alternatives to harmful animal use in tertiary education. *Alternatives to Laboratory Animals* 1999;27(6):967-74.


• Leathard HL & Dewhurst DG. Comparison of the cost effectiveness of a computer-assisted learning program with a tutored demonstration to teach intestinal motility to medical students. *ALT-J* 1995;3(1):118–25.


• Levine ED, Mills DS & Houpt KA. Attitudes of veterinary students at one US college toward factors relating to farm animal welfare. *Journal of Veterinary Medical Education* 2005;32(4):481-90.


Humane Teaching Methods Demonstrate Efficacy in Veterinary Education

http://www.veterinaria.org/revistas/redvet/n101008B/BA049.pdf

- Martinsen S. Norwegian School of Veterinary Science. Personal communication to Andrew Knight re: faculty opposition to humane teaching methods at the Norwegian School of Veterinary Science. 2002.
- Matthews D. Comparison of MacPig to fetal pig dissection in college biology. *Journal of Veterinary Medical Education* 2006;32(4):454-60.
- McCoy N. Willed deceased animals for veterinary medicine: the WAVE program. *The Outlook* [Western University of Health Sciences College of Veterinary Medicine newsletter]. 2003 Mar./Apr.
- McNamara T. Preparation prevents split-second decisions. *Alternatives in Veterinary Medical Education* 2001;18:2-3.
- Papp K. Ontario Veterinary College, University of Guelph (Canada). Personal communication to Andrew Knight re: faculty opposition to humane teaching methods and poor compliance with safety guidelines relating to chemically preserved anatomy specimens at the Ontario Veterinary College. 2006.
Humane Teaching Methods Demonstrate Efficacy in Veterinary Education


Pohost K. Veterinary students making a difference: in pursuit of ethical-source cadavers. Alternatives in Veterinary Medical Education 2001;16:2-3.


Humane Teaching Methods Demonstrate Efficacy in Veterinary Education

http://www.veterinaria.org/revistas/redvet/n101008B/BA049.pdf


- Thompson J. Veterinary students making a difference: new graduate emphasizes a continued need for moral and compassionate veterinary education. *Alternatives in Veterinary Medical Education* 2003;24:4-5.


