Theme 1
Education

Session 1.1
Refinement and reduction alternatives in education: Teaching humane science

Online Learning to Teach Humane Science

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Summary
The AALAS Learning Library (ALL) is a learning management platform that offers laboratory animal science courseware with documentation of training. Online learning in the laboratory animal field supports the 2Rs of reduction and refinement in animal use, and in addition, the ALL specifically teaches the 3Rs in courses where ethics is addressed. With now 103 courses, curricula are in development for users with technical, research, IACUC (ethical committee), management, training, and veterinary functions. Users are mainly in the USA, and international users from many countries worldwide are a growing faction.

Keywords: online learning, courses, courseware, training documentation, learning management

Introduction

Education and training programs for animal researchers focus on reducing the use of animals in research and on refining animal handling and treatment when animal use is necessary. As an adjunct to face-to-face training of research personnel, online learning provides depth in knowledge of concepts, prepares a learner for personal training, and reinforces lessons learned.

Options are increasing for the online education and training of scientists on the ethics of animal research. An online learning management system (or platform) has been developed by the American Association for Laboratory Animal Science (AALAS Learning Library at www.aalaslearninglibrary.org) and the U.S. Department of Veterans Affairs (www.researchtraining.org). Since the release of this platform in 2001, over 50,000 US researchers have completed ethics courses, and access continues to grow monthly at the rate of about 2,000 individuals. Currently, 457 institutions use this platform to train all research staff and 52 institutions use it to train a core group of animal facility staff.

This paper focuses on the progress made in the development of the AALAS Learning Library (ALL) in which AALAS has undertaken an initiative to expand the course curriculum of the AALAS Learning Library (ALL) to fully support the 3R's, particularly the R's of reduction and refinement, via promoting the competence of personnel in animal research. AALAS is developing curricula on the ALL for five functions for research personnel: research, technical, management and training, veterinary, and institutional animal care and use committee. Building competence with an emphasis on bioethics in each area of staff function will enhance animal welfare in research.

Platform

The ALL platform (fig. 1) is a learning management database in SQL Server that provides interactive courseware, transcript data for training activities, and automatic systems for enrolment, account purchase and renewal, user management, and author and administrative interfaces.

Course materials include text in html, interactivity via javascript, images, streaming media, practice questions, and exams. Multiple formats of questions are available for practice quizzes and exams. Feedback text may be incorporated in questions answered either correctly or incorrectly. Training activity is tracked by access of each page in a course, completion of a course, and passing of exams. Continuing education units (CEUs) are awarded on the basis of the completion of a course and the passing of the corresponding exam. Users may print a certificate on demand for CEUs earned.

Selected courses are free (*Working with the IACUC, IACUC Essentials, and Working with the Laboratory Mouse*, as well as some certification courses), but most are accessible only with an active account. An account provides access for one year to all courses including new ones launched during the term of the account. This approach of opening wide the door to every course through low fees and unrestricted access on the ALL lowers the barriers to receiving education and training.

To accommodate different sizes/types of institutions with varying needs, the ALL architecture provides access for both individuals and groups. A group may be an institution or an AALAS Branch organisation. Prices are reduced in individual accounts for AALAS members ($100 USD) and in group accounts for AALAS institutional/commercial members (lowest cost is $10 USD per person in a group of 150 or more persons).

In addition to the individual and group accounts, the ALL is structured for creating a custom library, in which specific courses may be selected for a custom curriculum and their materials may be modified to more closely support the needs of an institution's animal welfare program. The custom library allows an institution to educate and train large numbers of research staff combining both AALAS and institution-specific content. AALAS course offerings can be tailored to fit an institution's needs by adding or deleting material or images. (Only the certification courses are exempted from this capability since their content is tied to a suite of certification exams.) Moreover, through a simple authoring interface, institutional staff can both modify an existing course or create a new one. With a custom library set up for an institution, staff log in and enter their own institution's course library. The custom library model is intended help an institution address either short-term critical and long-term global training requirements. In 2004, for example, a university requested a custom library to meet their short-term goal in rapidly training 4,500 researchers on animal regulatory topics. Authorised individuals at the university customised the *Working with the IACUC* course, making it specific to their institution's policies and procedures, and this course was placed in a customised library that only university personnel could access. With the placement of that one course in their custom library and the distribution of login instructions to all personnel, the university staff navigated easily to the correct course and completed it without confusion.

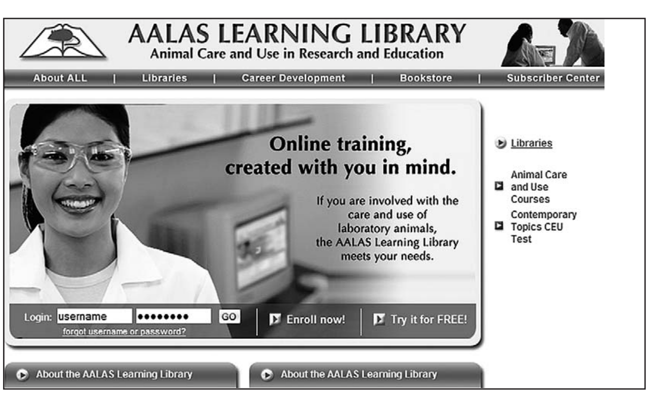

Fig. 1: AALAS Learning Library home page
(http://www.aalaslearninglibrary.org)

The ALL also incorporates automatic features to support administrative functions for users. A group has a Co-ordinator with authorities to manage the group's members, i.e., enrolling group members, assigning accounts to members, detaching members no longer associated with the group, viewing member transcripts, and downloading reports on member transcripts as Excel files or csv, txt, or html files. Users who purchase an account (Group Co-ordinator or individual users) receive automatic renewal notices and may view order history.

Any user may subscribe to the ALL listserv to receive announcements about the site, new courses, and information on how best to use the ALL platform.

Outcomes

Users

The ALL has 52 groups with 2,536 accounts and 80 individual users with accounts. Additional users who access the free courses without enrolling are not tallied. Although most users are based in the USA, 126 users are in countries in Europe, Latin America, the Middle East, Asia, and Oceania. For example, 6 New Zealanders recently obtained accounts through their membership of the AALAS Branch "Palms to Pines", which is located in California. Two institutions in Singapore enrolled their staff (a total of 21 persons) in group accounts to help them prepare for AALAS technician certification. The availability of the courseware 24 hours a day, 7 days a week, makes the ALL convenient to use in all world time zones. For persons outside the USA who are interested in attaining AALAS certification, the ALL offers the most economical way to study for all three examination levels. And, although no international group has a custom library at this time, a custom library would allow the production of courses on regulatory affairs and issues which are relevant to a country or region.

Courses

The AALAS Online Learning Committee oversees the curricula for the AALAS Learning Library (ALL) and has defined curricular goals for five functions ("training tracks") of animal facility/laboratory personnel: Research, Technical, Veterinary, Management and Training, and Institutional Animal Care and Use Committee (IACUC). These tracks serve to organise the course topics by staffing function. Because a subscriber may access any training track to take any course desired, the track feature accommodates persons with multiple duties (e.g., veterinary medical care, management, and technical procedures). In each track, the curriculum has objectives of imparting technical competence and ethical guidance on the use of animals in research. Research and IACUC courses feature US regulations, ethical decision-making, minimising pain and distress, and concepts of analgesia and anaesthesia. Additional research courses have topics of mouse bioengineering, mouse breeding, animal use methodologies, and facility operations. Certification-related courses prepare technicians to ascend the AALAS certification ladder, which provides qualifications to work with research animals and which is recognised by USA regulatory authorities. In the Management and Training Track, courses for trainers aim to impart skills for improving how to teach staff and test for knowledge retention. Management courses address facility operations plus human resource/supervisory skills. Veterinary courses relate to the field of laboratory animal medicine. Table 1 arranges series of courses by training track, and table 2 lists all individual courses available. Depending on the nature of the content, some courses overlap categories of staff function and so appear in multiple training tracks (tab. 1), whereas other courses are unique to a staff category and so are listed in only one corresponding training track. The Online Learning Committee members and AALAS staff will continue to produce courses in all categories.

The approach toward course development has been a broad-based effort to include experts in the laboratory animal field to co-author and/or review course materials. Contributors have joined these efforts via responses to listserv invitations for subject matter experts, by referrals following a presentation or paper of topical interest to a course in planning, and by general networking. As of August 2005, 132 individuals participated in the development of the ALL courses through contributions of content, questions, images, and media.

Ethics, and specifically the 3Rs, are repeatedly cited in courses that address animal use so that responsibilities toward animals are couched in these terms. An example of these is *Ethical Decision-Making in Animal Research* (Technical, Research, IACUC, and Management & Training training tracks). This course, developed with support by the Charles River Laboratories Foundation, teaches how to consciously think through a process for reaching an ethical decision in challenging situations in a research setting, such as whether to euthanise an animal prior to the end of a study. Distinctions are made among a range of outcomes that are ethically required, permitted, encouraged, and prohibited. Six steps are described in this approach to:

- Identify the ethical question raised in the case.
- Gather and assess all relevant facts.
- Identify the stakeholders.
- Identify the values that play a role in the decision.
- Identify possible solutions.
- Test out the decision by thinking what would follow if this decision were publicly known to be allowed in these kinds of cases.

Two related courses in the “Case Studies – a Trainer’s Resource” series offer case studies on ethical situations so one may practice working through the ethical issues of real-life situations in animal research. The case studies provide a worksheet for entering notes about each step of the ethical analysis. Case study printouts may be used for leading group discussions on the ethical dilemmas in research. Available within each case study course is a trainer’s resource of handouts and a guide which aid a group discussion on the case study.

The course and case studies were developed by Deni Elliott, PhD (the Poynter-Jamison Chair of Media Ethics and Press Policy at the University of South Florida.); Judy Murray, BA (Technical Training Coordinator, Charles River Laboratories); Stacy Marco, MBA, MS, LATG (Operations Manager, MD Anderson Cancer Center); Sally Walshaw, VMD (Director of Animal Resources, Atlantic Veterinary College); and Nicole Duffee, DVM, PhD.

User surveys

In December 2003 (5 months after launching the AALAS Learning Library) and again in September 2004, the AALAS Online Learning Committee invited all enrollees to take part in online questionnaires for user information and satisfaction.

In the 2003 questionnaire (78 respondents), most users (82%) said that they enrolled on the ALL to study for certification exams (36%), obtain continuing education (28%), or do their job better (18%). Users (82%) thought that it was easy to enroll in the ALL. Most users rated the courses as good (58%) or excellent (38%). When asked about what they liked best about the ALL, 28% liked the year-long access to every course, 31% liked the continuing education certificates, and 26% liked the transcript documentation.

In the 2004 survey (147 respondents), users again indicated that they were highly satisfied with the AALAS Learning Library: 77% reported that the ALL platform was easy to use, and 20% reported that access or navigation problems were rare. Most users (99%) rated the courses as good (40%) or excellent (59%). This survey provided a glimpse into the respondents’ educational backgrounds and job responsibilities showing the diversity among the individuals who use the ALL. Most users had either a bachelor’s degree (37%) or a high school diploma or GED (23%), and there were users as well with associate’s, master’s, and doctoral degrees. Most users worked as animal care technicians (26%), and many were also research technicians (17%), veterinary technicians (11%), facility managers (15%), scientists (6%), and facility directors/administrators (9%). Users expressed their preferences for courses mainly in regulatory and IACUC related topics (40%), as well as certification (28%), pain management (15%), and occupational health and safety (15%).

In each survey, open-ended questions allowed respondents to provide feedback and recommendations on course topics and platform issues. In response to specific comments, improvements were implemented wherever possible.

Conclusion

AALAS is committed to providing education on animal welfare and the 3Rs through all its educational resources and publications. The AALAS Learning Library extends that goal into online training in the laboratory animal field and supports the Rs of reduction and refinements in animal use. Knowledge in ethical and technical concepts in animal research is essential for both developing an animal protocol with the appropriate number of animals and conducting procedures which minimise the induction of animal pain and distress. Through the dissemination of online education and training, the AALAS Learning Library promotes the responsible care and use of animals in research to benefit people and animals.

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Tab. 1: Course and exam titles by training track on the AALAS Learning Library.
(The number of courses and exams are shown when there are multiples per title.)

Course and exam titles (Number of courses, exams if multiple per series)	Training tracks				
	Technical	Research	IACUC	Management & Training	Veterinary
Assistant Laboratory Animal Technician (29 courses, 33 exams)	÷				
Laboratory Animal Technician (14 courses, 18 exams)	÷				
Laboratory Animal Technologist (18 courses, 22exams)	÷				
Taking an AALAS Technician Certification Examination	÷				
Animal Welfare Act Regulations	÷	÷	÷	÷	
Public Health Service Policy on Humane Care and Use of Laboratory Animals	÷	÷	÷	÷	
Guide to the Care and Use of Laboratory Animals	÷	÷	÷	÷	
Good Laboratory Practice Standards	÷	÷	÷	÷	
Ethical Decision-Making in Animal Research (3 courses/exams)	÷	÷	÷	÷	
Pain Recognition and Alleviation in Laboratory Animals	÷	÷	÷		
Post-Procedure Care of Mice and Rats in Research: Minimising Pain and Distress	÷	÷	÷		
Working with the IACUC		÷	÷		
Writing a Protocol for Research in Animals (9 courses/exams)		÷	÷		
Essentials for IACUC Members			÷		
Introduction to Ergonomics in the Laboratory Animal Facility	÷			÷	
Ergonomics for Animal Technicians: Working Smart	÷			÷	
Biosafety in Microbiologic and Biomedical Laboratories	÷	÷	÷	÷	
Health Risks and Safety Procedures for Working with Nonhuman Primates	÷	÷	÷	÷	
Video: Working Safely with Nonhuman Primates*	÷	÷			
Working with the Laboratory Mouse	÷	÷			
Aseptic Rodent Surgery	÷	÷			÷
Mouse Breeding Colony Management	÷	÷		÷	
Genetically Engineered Mice: Historical Perspectives	÷	÷			
Genetically Engineered Mice: Approaches for Evaluating the Phenotype	÷	÷			
Transgenesis and Conditional Control Systems	÷	÷			
Biosecurity Issues Related to Genetically Engineered Mice	÷	÷			
Basic Metrics for the Laboratory Animal Facility	÷				
Selection of Cage Cleaner Products - Chemistry Driven				÷	
Workplace Training				÷	
Writing Multiple Choice Questions				÷	
Active Listening				÷	
Team Building				÷	
Time Management and Goal Setting				÷	
Introduction to Laboratory Animal Medicine					÷
Animal Observations and Clinical Signs of Disease	÷				÷
TOTAL Courses and Exams (103/109):	85/91	28/28	22/22	18/18	3/3

Tab. 2: Courses available on the AALAS Learning Library

Assistant Laboratory Animal Technician Level Courses
- ALAT 1: History and Purpose of Laboratory Animal Science and Animal Care Programs*
- ALAT 2: The Research Facility Environment*
- ALAT 3: An Introduction to Science
- ALAT 4: Cell and Tissue Structure
- ALAT 5: Organs and Organ Systems
- ALAT 6: Feed and Nutrition
- ALAT Review Exam (1-6)‡
- ALAT 7: Heredity and Breeding
- ALAT 8: Laboratory Animal Environment
- ALAT 9: Facility Equipment
- ALAT 10: Hygiene in the Laboratory Animal Facility
- ALAT 11: Animal Procurement
- ALAT 12: Health and Disease
- ALAT 13: Drug Therapy and Common Diseases of Laboratory Animals
- ALAT 14: Euthanasia
- ALAT 15: Experimental Design and Methodology
- ALAT Review Exam (7-15) ‡
- ALAT 16: Mice
- ALAT 17: Rats
- ALAT 18: Hamsters
- ALAT 19: Guinea Pigs
- ALAT 20: Gerbils
- ALAT 21: Rabbits
- ALAT 22: Cats
- ALAT 23: Dogs
- ALAT 24: Nonhuman Primates
- ALAT 25: Swine
- ALAT 26: Sheep/Goats
- ALAT 27: Amphibians
- ALAT 28: Birds
- ALAT 29: Miscellaneous Laboratory Animals
- ALAT Review Exam (16-29) ‡
- ALAT Final Review Exam (1-29) ‡

Laboratory Animal Technician Level Courses
- LAT 1: Public and Private Interests in Animal Research*
- LAT 2: Administrative Responsibilities*
- LAT 3: Laboratory Techniques
- LAT 4: Genetics and Breeding
- LAT 5: Anatomy and Physiology
- LAT Review Exam (1-5) ‡
- LAT 6: Laboratory Animal Facility Equipment
- LAT 7: The Laboratory Environment
- LAT 8: Animal Health Maintenance
- LAT 9: Health and Disease
- LAT 10: Diagnostic Techniques
- LAT Review Exam (6-10) ‡
- LAT 11: Aseptic Technique, Surgical Support and Anesthesia
- LAT 12: Emergency Veterinary Care
- LAT 13: Research Methodology
- LAT 14: Calculations and Conversions
- LAT Review Exam (11-14) ‡
- LAT Final Review Exam (1-14) ‡

Laboratory Animal Technologist Level Courses
- LATG 1: Functions of Management*
- LATG 2: Identifying and Controlling Costs*
- LATG 3: Regulations and Security
- LATG 4: Quality Assurance
- LATG 5: Occupational Health & Safety
- LATG 6: Structure and Function of Cells and Tissues
- LATG 7: Organic Chemistry and Biochemistry
- LATG 8: Molecular Biology
- LATG 9: Genetic Engineering
- LATG Review Exam (1-9) ‡
- LATG 10: Infectious Diseases
- LATG 11: Immunology
- LATG 12: Common Diseases of Laboratory Animals
- LATG 13: Diagnostic Techniques
- LATG 14: Pharmacology
- LATG 15: Anesthesia and Analgesia
- LATG 16: Unique Anatomical Features of Some Laboratory Species
- LATG 17: Gnotobiology
- LATG 18: Statistics
- LATG Review Exam (10-18) ‡
- LATG Review Exam (1-18) ‡
- Taking an AALAS Technician Certification Examination‡

US Federal Regulations and Guidelines
- Animal Welfare Act Regulations
- Public Health Service Policy on Humane Care and Use of Laboratory Animals
- Guide to the Care and Use of Laboratory Animals
- Good Laboratory Practice Standards

Bioethics
- Ethical Decision-Making in Animal Research
- Ethical Case 1: Mouse in a Parasitology Experiment
- Ethical Case 2: Rat with Partial Paralysis

Pain and Distress Management
- Pain Recognition and Alleviation in Laboratory Animals
- Post-Procedure Care of Mice and Rats in Research: Minimizing Pain and Distress*

IACUC Courses
- Working with the IACUC: VA version*
- Working with the IACUC: non-VA version*
- Essentials for IACUC Members*

Writing Animal Protocols
- Writing an Animal Protocol for Research on Mice*
- Writing an Animal Protocol for Research on Rats*
- Writing an Animal Protocol for Research on Rabbits*
- Writing an Animal Protocol for Research on Guinea Pigs*
- Writing an Animal Protocol for Research on Hamsters*
- Writing an Animal Protocol for Research on Gerbils*
- Writing an Animal Protocol for Research on Dogs*
- Writing an Animal Protocol for Research on Cats*

Occupational Health & Safety
- Introduction to Ergonomics in the Laboratory Animal Facility
- Ergonomics for Animal Technicians: Working Smart
- Biosafety in Microbiologic and Biomedical Laboratories
- Health Risks and Safety Procedures for Working with Nonhuman Primates
- Video: Working Safely with Nonhuman Primates*

Mouse Biomethodology
- Working with the Laboratory Mouse*
- Mouse Breeding Colony Management
- Genetically Engineered Mice: Historical Perspectives
- Genetically Engineered Mice: Evaluating the Phenotype
- Transgenesis and Conditional Control Systems
- Aseptic Technique for Rodent Survival Surgery

Math
- Basic Metrics for the Laboratory Animal Facility

Cage Washing
- Selection of Cage Cleaner Products - Chemistry Driven

Management & Training
- Writing Multiple Choice Questions
- Workplace Training
- Active Listening
- Team Building
- Time Management and Goal Setting

* Course can be taken without having an account, but there is no transcript documentation.
‡ These courses are designed to help individuals prepare for the certification exams, they do not provide CEUs.

Three Barriers Obstructing Mainstreaming Alternatives in K-12 Education

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Summary
The limited use of alternatives in secondary education contrasts with the concerted adoption of alternatives in veterinary curricula. Taking a teacher's perspective, three barriers obstruct mainstreaming of alternatives in high school biology courses. First, dissection is not addressed in course outlines, curricular standards, and frameworks. Second, financial and technical support for resources in science teaching is lacking. Third, teachers need ways to motivate their students to learn biology and offer them stimulating, informative materials. Preparation of appropriate materials for five to ten biology laboratories could address these three barriers at modest cost and effectively deliver biology to secondary students.

Keywords: biology, secondary education, dissection, teaching, alternatives, intermediate education, physiology, systems

Introduction

Using dissection or experimentation with animals as a method of teaching students has a colourful and contentious history (Tansey, 1998; Klestinec, 2004). Ideas in science education have evolved through the nineteenth and twentieth centuries (DeBoer, 1991), yet the use of animals in laboratories of secondary schools in the United States has continued with little change or educational scrutiny.

Considering the uses of animals in research, teaching, and testing, the uses in education seem most amenable to replacement, the most sought after of the 3Rs. Indeed, veterinary schools increasingly have mainstreamed alternatives in their curricula and a large number of teaching resources are available (Hart et al., 2005), but widespread adoption of alternatives has not yet occurred for teaching high school biology in the United States. Monitoring the use of animals in education, while not a comprehensive effort, indicates there has been a sharp reduction of animal use in higher, medical, and veterinary medical education, but perhaps less reduction at the secondary level. Having a substantial replacement of animal use in the advanced education and training of veterinarians, but still using many animal specimens in high school teaching, looms as a growing paradox that continues as a subject of criticism and controversy.

Consistent with the adoption of alternatives in higher education, an ever-growing supply of resources exist, almost 4,000, that are cataloged in the NORINA database (Smith, 2005). Some of these resources are categorised and described in the InterNICHE book and website (Jukes and Chiuia, 2003; InterNICHE, 2005), as well as the AVAR website (AVAR, 2005). Both traditional and alternative resources, including dissection materials and various models, are advertised widely by distributors (Carolina Biological Supply Company, 2005; NASCO Online Catalogs, 2005). Despite this great number of resources, secondary school teachers still are not offered and provided a well-integrated package of resources that interface with and complement the curricular lessons for courses in high school biology and physiology.

Over the years, papers and books concerning opposition to use of animals in education have presented relevant analyses, including reviews of ethical considerations for alternatives (Langley, 1991), and the patterns of use in the United States (Orlans, 1991), in other countries (Balcombe 2000a), and in higher education (Balcombe 2000b). Reflecting the controversial nature of the topic, in some papers, the posture has been frankly political or philosophical, arguing that we should or should not allow dissection (Sapontzis, 1995; Kline, 1995). Much of the controversy concerning animal use in secondary education has focused directly on communication with students, providing legislated protection to those who prefer to use alternatives and coaching them in strategies to avoid dissection (Balcombe, 1997a). Another topic, again focusing on students, has been considering the adverse ethical consequences of instructing students to be involved in harming or killing animals (Orlans, 2000).

A study from England reported on a survey of 468 students regarding their experiences with and attitudes toward animals in education, including dissection (Lock and Millett, 1992). A subsequent survey assessed the use of animals from the teacher's perspective (Adkins and Lock, 1994). About a third of the teachers held opinions that discouraged them from using animals in their teaching. In an Australian study, all 34 surveyed schools reported doing dissection, limited primarily by cost, and almost all schools also included activities with living animals (Smith, 1994). A retrospective study in Canada sought to document students' experiences and attitudes, both positive and negative, concerning dissections they performed in secondary school (Bowd, 1993). Lock (1994) replied, agreeing with many aspects of Bowd's paper, but differed in having the view that no alternatives were superior to dissection. An ethnographic study was conducted later to learn more about the reactions of students to their experiences in dissection (Barr and Herzog, 2000). Like Bowd, they found that a substantial minority viewed dissection primarily in negative terms.

Comparing the performance and achievement of high school biology students who use simulated dissection versus actual dissection, the simulation was equally effective for learning (Kinzie et al., 1993). A review of various studies using simulated alternatives for teaching anatomy, at various academic levels, also found that simulations yielded similar achievement outcomes as live dissection, whether using low-tech or high-tech simulations (Zirkel and Zirkel, 1997). Yet another approach has been to use the simulation as a preparation for the dissection, resulting in the students learning more anatomy following the dissection (Akpan and Andre, 2000). In general, the issue of dissection appears to have been most visible during the late 1980s and early 1990s, then giving way in the educational community to emphases on standards, curricula assessment, and diversity. Dissection is strikingly absent from published materials on standards and frameworks.

With these laboratories, there may be a gap between the objectives set for the laboratory and the accomplished outcomes associated with the expected learning (Ralph, 1996). A recent assessment of laboratories in U.S. high school science curricula by the National Research Council has concluded that, in general, the quality of current laboratory experiences is poor for most students, and that improving high school science teachers' capacity to lead laboratory experiences effectively is critical (Singer et al., 2005). Additional criticism was levelled at the organisation and structure of most high schools, the state science standards, and the current large-scale assessments. Similar criticisms were reported from an earlier study of the laboratory work in British Columbia High Schools, a report that called for substantial research and reform (Gardiner and Farragher, 1999).

These varied perspectives have not considered the constraints teachers face, but rather have criticised teachers. Balcombe (1997b) evaluated some of the barriers against acceptance of alternatives in teaching, including that some teachers are resistant to change; it requires investing time and money; information on alternatives is not widely disseminated; and the quality of material available varies. In more recent writings Balcombe (2001) has directly made a case for adoption of alternatives rather than using dissection. In this presentation, we build on the paper by Balcombe (1997b) concerning the barriers against acceptance of alternatives. Taking the teachers' perspective, we propose three barriers mitigating against rapid adoption of alternatives in classrooms, recommending production of web-based teaching resources to address these barriers and improve instruction in biology laboratories, especially within the United States.

Methods

Two groups of pre-college teachers participated in discussions that contributed to this paper. A group of 23 teachers worked with us during the academic year, 1993-1994, using instructional software, "The Virtual Heart", in their classrooms (Zasloff and Hart, 1997). During 2003-2004, 5 teachers participated in a focus group and subsequently continued as consultants in further discussions. The teachers all were teaching in public junior or senior high schools in the Sacramento Valley during the period of their participation.

Barriers against adoption of alternatives

Teachers generally are highly motivated to employ the best teaching materials and resources they can feasibly acquire, often even purchasing materials with their own funds. Although the topics of biology that lend themselves to dissection are interesting to students, the curriculum is very full with information required to be taught, leaving little laboratory time for most teachers when teaching mammalian biology. Commonly, about five laboratory sessions are scheduled, sometimes as double periods. Occasionally, a semester-long physiology course is offered, permitting more extensive laboratory experience for the students. In these contexts, teachers typically offer some type of dissection experience, though faced with the three barriers described below.

1. Dissection not addressed in curricular materials and frameworks

A curricular gap exists. Though traditional and common within intermediate and secondary school biology classrooms, the practice of dissection is seldom mentioned within science education research, national curricular standards, and science frameworks. It has not had prominence in the past decade as a topic of importance. It does not appear in course outlines, and no major dialog concerning science curricula includes a consideration of dissection. Thus, there is no prominent platform where teachers and educational professors discuss methods for presenting laboratories involving dissections or alternatives. Teachers need to figure out for themselves how to structure these laboratories in their classrooms.

2. Phase-out of teaching resource centers

Instrumental and technical supportive resources for science laboratories have been sharply reduced across recent decades. County educational districts formerly provided resource materials that were integrated with specified laboratories for lesson plans and supported by specialists providing assistance with subject matter. These centers providing teaching resources have been dismantled. Teachers are on their own to acquire and accumulate teaching materials when needed to enhance their courses. The small budgets that are provided are only sufficient for purchasing a few clerical supplies. Abundant resources are available commercially, but they are costly and not presented as an integrated set of resources for high school biology (Weng et al., 2004a, 2004b). A few resources are available on loan, for example from Animalearn (2005) or the Humane Society of the United States (2005), but this requires planning well ahead and scheduling for particular lesson plans. The gap in the curricula and resources for science laboratories sets a stage for the third barrier.

3. Teachers' goal to motivate and interest students

To teachers, supplying motivating and informative materials for students in classrooms is of prime importance. Teachers enter the profession dreaming of motivating students to learn, but are hampered in achieving their dream. They seek to inspire their students. In high school biology, a worthwhile laboratory exercise that would mark a quality experience for students is difficult for teachers to muster. Whether to use animal specimens and other resources in high school classrooms is not considered within the texts of curricular standards and science frameworks, nor are such resources and relevant expertise offered by school districts. Thus, the teachers' highest goal of inspiring their students in biology becomes ever more unattainable. A common question from teachers is, "How can we engage them?"

Solution to adoption of alternatives

The curricular requirements for teaching some laboratories in high school biology are relatively simple and straightforward, and could improve basic education in biology for students across the United States. In crafting a solution, it is critical to recognise that teachers have limited time available for laboratories on these topics; the resources required to meet their needs are not great. Even five outstanding laboratories produced in software and made freely available on the web could revolutionise biology laboratories in many classrooms. As a start, appealing software on the virtual mammal covering five basic laboratories on the skeletal-muscular, respiratory, digestive, nervous, and circulatory systems would provide a solid basis of education. With additional resources, the urinary, lymphatic and immune, skin, and endocrine systems could be added, plus organs such as the heart, brain, lungs, kidney, eyes, and ears, and joints such as the knee, hand, and foot, addressing the major needs of high school teachers. The teachers could complement these materials with other resources that they acquire.

Considering the number of students who could benefit from these improved teaching resources, the cost of preparing such software would be small. One possibility could be an increased commitment to this objective by animal advocacy groups (Fleischmann, 2003).

Conclusions

Teachers of high school biology often retain the traditional pattern of offering dissection of an animal. They seek new and improved resources, and consider using those that are easily accessible. But they are provided almost no budget for their laboratories, so are left to improvise and scavenge when designing the laboratories they offer. The disappearance of resource centers from school districts isolates teachers as they approach this quandary. The overriding motivation of teachers is to stimulate their students to enjoy learning. Dissection remains a favored avenue for providing an engaging experience to students. Production of five to ten outstanding software units on basic physiological systems could establish a solid foundation for secondary school biology laboratories everywhere.

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Should Live Animals be Used when Educating Future Biomedical Scientists?

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Summary
Animals are used for various purposes in education of scientists including: 1. Demonstration of biological principles, 2. Surgical education and training, and 3. Education and training of biomedical scientists for licensing.
This paper advocates a gradual replacement of animals for demonstration of biological mechanisms with non-sentient materials. It explains why animals remain necessary for training of surgeons, and why it is important for the welfare of laboratory animals that future scientists have passed a course demonstrating that they can handle and restrain animals, and perform routine procedures on anaesthetised animals before they can be granted a license to perform animal experiments.

Keywords: education, training, licensing

Introduction

The present Proceedings demonstrate that refinement is fortunately no longer the Cinderella of the Three Rs (Russell and Burch, 1959) as Hau and Carver wrote in 1994 – a term later adopted by van Zutphen (1998). There is now a general awareness of the importance of refinement in ethics committees and in the scientific community, as demonstrated by an increasing implementation of the Three Rs in biomedical research (Hagelin et al., 1999a and b, 2003; Hau et al., 2001; Carlsson et al., 2004).

The use of live animals for teaching and training purposes is controversial. The animals used obviously do not directly contribute to important new biomedical discoveries. Indirectly, however, they certainly do contribute, just as they contribute to the reduction of human morbidity and mortality associated with surgical treatment. To the uninformed public it may seem that this particular use of animals could appropriately be replaced by audiovisual material, new elegant interactive computer-based learning programmes and artificial models of animals and man. The welcome, rapid development in these new tools certainly contributes to a reduction in the number of animals needed for teaching and training, but they cannot completely replace the need for live animals. It is important, however, to be aware of the development of new alternatives and to implement these continuously, replacing live animals in teaching and training programmes, as and when these new devices and programmes become available.

Animal use in teaching and training

Live animals are presently used for different purposes in the education of physicians, veterinarians and scientists. These include the following:

1. Demonstration of physiological and pharmacological principles
   - Undergraduate medical and veterinary programmes
   - Undergraduate and post graduate science programmes
2. Surgical training
3. Training biomedical scientists for licensing

1. Demonstration of physiological and pharmacological principles

Many medical schools and veterinary schools have traditionally used anaesthetised animals in non-recovery demonstrations in practical classes to demonstrate principles and mechanisms of physiology and pharmacology, and many still do. Many new medical schools, however, have chosen not to use live animals in the curricula for undergraduate students and many old schools are revising their practicals, substituting animal-based practicals with, for instance, a combination of interactive computer programmes and extended practicals in which the students themselves are the guinea pigs. That there is indeed a plethora of new alternatives to live animals in this particular field is obvious to the reader of these Proceedings.

The need for live animals in the education of pre- and postgraduate science students is perhaps more difficult to substitute 100% with non-sentient material without compromising the quality of education. It seems likely, however, that looking more carefully at this level may also yield a reduction benefit. FELASA's policy statement on animals in teaching advocates replacement whenever possible, "The use of live animals in other teaching programmes, e.g. pharmacology and physiology for undergraduate students, to demonstrate fundamental biological interactions should be replaced with alternative methods as and when these become available" (http://www.FELASA.org). From an ethical point of view it is important to emphasise that vertebrates used in undergraduate curricula are generally anaesthetised prior to the practicals and euthanised at the end of the practical. Since the animals are unconscious and anaesthetised, they are not subjected to pain, distress or suffering.

2. Surgical training

Surgical education and training in new surgical procedures and techniques require the use of live animals, but it is probably possible to reduce the need for animals by a more extensive use of cadaver material and increasingly elaborate artificial models available on the market.

Training in microsurgery is traditionally dependent on live anaesthetised rats, and, although the initial phases of a training programme may well make use of artificial models, the final stages of the training require live animals – traditionally rats. This is well recognised and, in the UK for example, routine training of surgical techniques on animals is normally only allowed under supervision of operations or experiments, with a few exceptions, including training in microsurgery (Home Office, 1986). It is difficult to envisage that live animals can be completely replaced for this purpose in the foreseeable future.

The use of animals to train manual skills has been the subject of debate in Europe for several years, and in certain countries it is not permitted. In at least one major European country, animals may not be used in the teaching of laparoscopic techniques. Early mortality and morbidity figures were disappointing in this country, because the surgeons had not been trained on live animals. Consequently, a very large number of surgeons from this country have now been trained in minimal access surgical techniques abroad. This clearly demonstrates that animals remain vital for training of surgeons in minimal access surgical procedures.

Small numbers of animals – traditionally pigs – are used to train surgeons in war surgery, an activity which unfortunately continues to be highly relevant for humanitarian reasons. Fully anaesthetised pigs are shot at, and surgeons train how best to repair the damages assisted by veterinarians responsible for adequate anaesthesia of the animals. These practical exercises are non-recovery and are thus not really an ethical issue.

The use of animals in experimental surgery must thus be considered vital for human health, and there are certain indications that there is an increasing demand from surgeons for access to training facilities. This may be associated with the trend towards shorter working weeks for surgeons in various European countries, making it difficult for them to obtain the necessary routine and requirements for specialisation through their activities at the hospitals.

Rapid advancements in surgical techniques often require access to animals for research and development projects.

3. Training biomedical scientists for licensing

Training scientists in the most humane handling and procedural techniques. The utilisation of live animals in experimental biomedical research requires a certain level of knowledge and manual skills of the scientist who is the responsible license holder. This is well known and recognised among researchers and veterinarians because of its importance for upholding the quality of scientific results (Cohen, 1966) and safe-guarding the welfare of the animals used. The current European legislation requires individuals involved in research performed on animals to have adequate education (ETS 123, Council of Europe, 1986). The level of competence needed is usually not defined in laws and regulations. These decisions are left to those responsible for the animal experimentation on an institutional, regional or national level. It has long been argued that education in laboratory animal science should be strengthened and harmonised in Europe (Rozemond, 1991), and that FELASA should take the lead in this process. FELASA has done so and worked out guidelines for curricula, at four consecutive levels of competence, which should lead to adequate knowledge and skills for different categories of scientific and technical staff. In an increasing number of European countries the practice is now that the level of competence required for scientific staff that allows independent work with animals is the FELASA category C curriculum (Wilson et al., 1995). Thus, all new scientists, predominantly PhD students, have to complete this course and a written exam before they are allowed to work independently on animal experiments and before they can obtain a license to work with laboratory animals. FELASA's accreditation board for teaching and training programmes and courses is presently accrediting an increasing number of C-courses throughout Europe.

Practical training in correct handling, sampling and administration of substances must be considered essential components of the FELASA C course for biomedical scientists, who wish to obtain a license for animal experimentation. The FELASA statement on the use of animals in training courses reads as follows: "FELASA categories C …. courses must contain practical classes in which the participants are taught humane handling and restraint as well as modern and humane methods for blood sampling, administration of substances, anaesthesia and euthanasia."

Requiring that scientists, who wish to obtain a license to experiment on animals, must pass a course in which they are taught – among other important things – how to handle animals in the most humane way possible, how to restrain them so that the animals do not feel fear, and how to euthanise animals as well as how to perform the most common routine procedures (injections and blood sampling) seems to be an absolute minimal requirement. The overall goal is to help students approach their animals with greater insight and confidence than if they had to acquire the necessary knowledge and experience on their own, supervised by their scientific supervisor. The courses aim to give the students the basic knowledge and experience necessary to successfully continue acquisition of further practical skills during their experimental work. It is sometimes argued that new scientists could learn these attitudes and skills from experienced scientists, but there are more cons than pros of this old-fashioned system. It would be difficult to establish an assessment system where the practical skills of the new scientist were objectively assessed before he/she was found competent. On-the-job-training would also result in an uneven quality of teaching with no uniform standards, and this is not an area where it is acceptable to learn from one's own mistakes. A quality assurance system would also be difficult to operate without implemented accredited standards for practical training.

The numbers of animals used in training programmes is miniscule compared with research use and it must be considered essential from an animal welfare point of view that new scientists are taught how to restrain animals without causing fear and stress to the animal, as well as how to anaesthetise them. Once the animals are anaesthetised, the course participants can learn all relevant sampling techniques as well as administration of substances, after which the animal is killed and dissected for comparative anatomy. An important feature of training courses is the instruction and training in methods of humane killing. Some euthanasia techniques require more skill than others, and, in particular, physical methods like cervical dislocation should only be attempted by experienced personnel who have received sufficient training to allow them to use these methods confidently and effectively.

Discussion

Although it is often claimed that there is strong opposition to the use of animals in training programmes, this is not supported by looking at course evaluation forms. The author has taught postgraduate students for more than 25 years at universities in Denmark, the UK and Sweden, and the vast majority of students are extremely positive about the use of animals in training programmes. It goes without saying that it is important to show respect for the animals used and to demonstrate thoroughly how animals are picked up, restrained and anaesthetised before the students attempt this themselves (Hau, 1999). In addition, such courses should also foster a caring attitude to animals (van Zutphen, 1991), and teach appropriate and ethical treatment of animals (Ninomiya and Inomata, 1998). The importance of habituating animals to all staff including the scientists with the aim of lowering animal stress and increasing the pain threshold must also be emphasised, and it is important to teach how positive reinforcement training can help lower the stress of the animals as documented by Lambeth and co-workers (2005). Exercises with dummies, videos or interactive computer software cannot fully substitute for practice on live animals (Adam, 1993). Lack of proper training of future scientists may add variance in research results and increase the risk of future malpractice, thus compromising animal welfare. An introduction to the personal practice of the most efficient and humane experimental techniques through a high quality course ensures that future scientists will know how to treat their experimental animals with maximal consideration of animal welfare (Hagelin et al., 2000a).

The students attending our FELASA category C courses at Uppsala University 1997-2000 were asked to complete a detailed course evaluation in connection with the written exam at the end of the course (Carlsson et al., 2001). The forms were collected and processed anonymously. After completing the course, the majority of the students (>93%) were convinced that the subject was of great importance ($p<0.0001$). None of the students considered it to be of little importance after attending the course. It is noteworthy in the present context that more than half of the students (57%) found practical handling including experimental procedures the most important topic taught during the course. In particular, hands-on laboratory activities, like handling of and procedures (sampling and administration) on rats and mice scored highly (averaging >3.8 on a scale from 1 to 4). These results have been confirmed by a recent follow-up study (Abelson et al., 2005).

Compulsory courses are challenging, because they are not necessarily attended out of interest and motivation. The mandatory course in laboratory animal science taught at Uppsala University is no exception. It should be emphasised that since these courses are mandated, they have to be effective and perceived as highly relevant. There are few previous studies on attitudes towards courses in laboratory animal science. However, the Uppsala results seem to confirm the findings in a survey performed by the American Medical Association where 91% of physicians stated that the use of animals had been important for their training and 93% expressed support for continued use of animals in medical education (American Medical Association, 1989). Studies have shown that experienced teachers find that hands-on laboratory activities with animals add significantly to learning biology (Keiser et al., 1991; Mayer and Hinton, 1990; Offner, 1993). A recent study of veterinary students suggested that out of those who changed their view on whether or not it is morally acceptable to use animals for teaching, 26% became more receptive to the use of animals in research. The most frequent comments were that the course had given them a greater knowledge, a better understanding of the necessity of using animals for medical progress, more accepting and tolerant views and a less prejudiced view of the use of animals (Hagelin et al., 2000b).

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