Technological Advances that Enhance Teaching Using Animals, and the Application of the Three Rs

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Summary — The inventions that have progressively contributed to education have never offered opportunities as vast as in the digital era, even though this is still scarcely 25 years old. In this time, digital handling of data led first to text processing, then to bitmap and vector graphics, and now, to digital sound and movies. As these advanced, the storage methods became larger, faster, easier and cheaper. The advancement of technology has been so rapid that the standard of most teaching aids now available is well below what can currently be achieved. We are confronted with an unprecedented opportunity for applying the principles of *reduction, refinement* and *replacement* of animals in education. Not only are the visual teaching aids improved by digitising, but all aspects of their development, including the ease, higher speed, and low cost of creation, editing, copying, distribution and access, are improved, as well. Several examples will be given, including access to interactive panoramic movies, animated sequences to explain difficult concepts, on-line tutorials and image databases using digital photography, radiography and other diagnostic methods, as well as the production of desktop movies. The speed of technical advance brings its own problems, but the challenges and possibilities for developing viable alternatives to the use of animals in teaching are vast.

Key words: *dissection, teaching, technology, Three Rs.*

Introduction

Given a long tradition of dissecting animals to enhance learning about them, and not being willing to lower the standard of teaching, we have an option of either maintaining the *status quo*, reducing the animals used to some extent while refining this use with alternatives, or entirely replacing the animals used with alternatives. This first option, to continue with traditional methods, is under increasing pressure. The use of animals is expensive, and the technical skills necessary to prepare them for dissection are less appreciated and are more difficult to retain. Classes are becoming larger and proportionately expanded, while proportionately larger facilities are not always provided. With new courses added and with changing emphasis within curricula, traditional disciplines now have severe constraints on time, personnel, animals and resources. There is some realisation that traditional methods are not necessarily ideal, or even adequate, for all teaching objectives. Added to all this are the ethical issues of animal use and student expectations that they should have choice as to how they learn and that alternatives will be available to them. To try to replace animal use entirely presupposes that we have developed satisfactory methods to achieve this. Alternatively, the middle way of reduction and refinement provides teachers and students with choice, while the methods are progressively explored and evaluated. Some progress in this direction is described here, with an emphasis first on the necessity that successful resources must be easy to develop, and secondly, that the best tools to achieve progress are also very new.

The Digital Revolution

For over 25 years, the processing speed of the silicon chip has exponentially increased, with no sign of abating. From the initial use for dealing with numbers, desktop computers have been predominantly used by students for text processing, for both creating and communication. But numbers and text have little to do with the replacement of animals in learning. Even with the addition of pictures, created either in bitmap or vector graphics, computers made little more progress in this respect than did illustrated books. However, software then began to enable students to respond to graphical and auditory cues, a multimedia interaction that has steadily improved with the quality of the graphics and processing speed. It is most significant that the production of graphics by the use of digital cameras and digital photographic processing has never been easier. Inexperienced teachers can now create high quality images, bypassing expensive professional photography and printing.

Movies with sound editing are now easy for teachers and their students to produce on entry-

level home computers. Interactive media, as used in the parlour games industry, now outstrip cine, video and television in their potential for assisting learning and in replacing animals with virtual reality.

Unlike historical revolutions that have been isolated to geographical regions and particular peoples, the digital revolution is truly international: one animal in the global village can potentially teach the whole world as images of it spread on the Internet. Examples to show recent developments follow.

Interactive movies

Interactive digital movies are easily made in QuickTime VR (1) from a series of still digital pictures. Objects can be rotated, enlarged or reduced for exploration of all surfaces. If these objects are animal parts, there is little need to use animals to continually replace them. Panoramic views create the effect of scanning over a dissection, but in the virtual view, particular items have hotspots that connect to special information or challenges. The effect of immersion of the viewer within an organ, such as the stomach of a sheep, is not difficult to create.

Medical imaging

Many other internal views of the body can be made using endoscopy, relatively non-invasively and frequently, as a by-product of clinical investigation. These are more effectively shown as QuickTime (2) movies than by still frames. Such studies include views of the upper digestive and respiratory tracts, the stomach and parts of the reproductive tract. Similarly, the action of joints and the function of internal organs when radiographically contrasting material is being swallowed can be well observed by fluoroscopy. Speech can be added to digital movies made from video obtained by a variety of medical imaging methods, especially ultrasound, so that the teacher can create on-line tutorials that closely follow the movement that the student observes. Viewing the anatomy of the heart from echocardiographic images of the living organ and viewing the anatomy of the female reproductive tract at different stages of gestation demonstrate physiological variation in a clinically relevant way.

Desktop movie editing

Until recently, movie editing required a substantial studio with expensive equipment and highly skilled assistance. Few teachers created video independently. With the digital revolution, digital editing software such as Apple's iMovie (3) comes bundled free with entry-level computers, and school children operate digital movie cameras to create their own projects, with added sound and commentary. Since analog VCRs are still a common delivery medium, it is useful that digital video can be copied to analog tape.

Computer graphics and animations

The linking of drawings by animation techniques is limited only by the teacher's imagination. Some preliminary experiments include a tutorial explaining a method for appreciating the tomographic relationships of organs inside a living cow, so that a student with only a basic understanding of the structures involved can spend more time considering living animals from the outside than by traditional anatomical methods. Another attempt with real potential is to animate various organs with close functional associations, so that, for instance, the structures making up the tongue are connected to their blood supply and drainage, their lymphatic drainage, and their motor and sensory nerve connections to the brain, all placed in their correct topographical position. Such associations are difficult to make clear by other means.

Graphics databases

Using a feature of WebCT (4), the software package that many universities use to manage web-based teaching, several databases are being constructed as a Veterinary Virtual Museum (5). Containing nearly 400 records, the anatomy database includes the set of digitised radiographs previously taught using displays of plates, but now annotated, often accompanied by images with overlaid bone outlines, and fully searchable using the various fields. The database also contains images derived from other medical imaging techniques, such as X-ray and magnetic resonance imaging (MRI)-computed tomography. The recent use of digital photography has enabled dramatic improvement in the ease and quality of images of anatomical subjects, many of which are of items displayed in our museum, but which have always been difficult to present to students in an inspiring way, and linked to relevant learning tasks. Others are of displays of fresh material that can only be repeated every year at high monetary and ethical cost. Some of the records are photographs taken of items in museums overseas. The potential for this database to include the best of each type of teaching resource, contributed by teachers internationally, is still relatively untapped.

On-line quizzes

The same Web CT-based software also has the ability to provide easily created quizzes, accessed by a web browser, using the same kind of images as in the database. The question formats include short answer, multiple choice and the matching of several images to their descriptions.

On-line tutorials

A software package developed at Massey University and available free of charge enables the creation of tutorials with speech, graphical images and basic animation, with little training and great effect that are then converted to web-based and indexed packages. Audiograph (6) has been used to create "prelabs" that are designed to help students by explaining difficult concepts, so that they gain more from their laboratory experience. The tutor talks through the subject, pointing out relevant structures as the tutorial proceeds. But unlike a real tutorial fixed in time and place, these virtual tutorials can be accessed anywhere and at any time, and played, stopped and repeated according to an individual's needs.

Conclusions

At the current rate of technological acceleration, total replacement of animal dissection in teaching even veterinary students, for whom direct contact with animal tissues is better justified than for other students, will certainly be attainable in the near future. Meanwhile, there is much exploration to be done as the horizons expand. There is an immediate challenge to make the best teaching aids accessible, at low cost, to all students, wherever they may be. To this aim, we are working to ensure that many of the developments at Massey University will become available for evaluation, constructive criticism and use, as freely and widely as possible.

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