Computer-Based Alternatives in Higher Education – Past, Present and Future

David Dewhurst
Learning Technology Section, College of Medicine & Veterinary Medicine, University of Edinburgh, UK

Summary
Many thousands of animals are still used annually in tertiary education despite efforts by enthusiastic teachers to reduce this number by developing and making available to their colleagues a range of alternatives. Technology-based alternatives which support replacement and reduction are at the forefront of these efforts. Persuading teachers to use them is critical and strategies to raise awareness and support the integration of the alternatives into teaching are described. Many of the existing computer-based alternatives were developed in the early 1990s and rapid changes in the technologies used to deliver them have rendered them difficult to use and in some cases obselete despite the fact that their content and educational design are still valid. A project, using a learning object approach to development, which aims to preserve the content and educational design, improve the flexibilty of delivery and enable teachers to edit the content, is also described.

Zusammenfassung: Computer-basierte Alternativen in der Hochschulbildung - bisher, jetzt und in Zukunft
Viele tausend Tiere werden immer noch jährlich in der Hochschulbildung verbraucht, obwohl enthusiastische Lehrer diesem entgegenzuwirken versuchen, indem sie eine Reihe von Alternativmethoden entwickeln und entwickelt haben und diese ihren Kollegen zur Verfügung stellen. Technologie-basierte Alternativen, die den Ersatz und die Reduktion von Tierversuchen fördern, sind an vorderster Front dieser Bemühungen. Es ist heikel, die Lehrenden von diesen Methoden zu überzeugen, damit sie auch eingesetzt werden. In diesem Artikel sind Strategien beschrieben, durch die der Bekanntheitsgrad von Alternativen und die Integration von Alternativen in die Lehre verbessert werden können. Viele der erhältlichen Computer-basierten Alternativen wurden in den frühen 1990ern entwickelt, und die schnellen technologischen Entwicklungen in den Transfertechnologien haben ihre Anwendung erschwert und in manchen Fällen unmöglich gemacht, trotzdem ihre Inhalte und ihre pädagogische Ausgestaltung noch aktuell sind. Hier wird ein Projekt beschrieben, in dem durch einen Lernobjekt-Ansatz, der Inhalte und pädagogische Ausgestaltung enthält, eine bessere Flexibilität bezüglich des Transfers gewährleistet wird und den Lehrenden erlaubt, die Inhalte anzupassen.

Keywords: Computer-based alternatives, replacement of animal use in teaching, pharmacology teaching, biomedical education

1 Introduction

In the UK, in common with most countries in the world, animals are used in teaching, mainly in tertiary institutions and in biomedical disciplines such as pharmacology and physiology. Although, where official figures are available, the number of animals used for educational purposes is small i.e. less then 1% of the total used for research (Casati and Hartung, 2003). This still means that education accounts for the use of many thousands of animals each year much of which, it could be argued, is unnecessary. The reported figures are also often misleading since, in many countries including the UK, animals which are killed just prior to use would not be counted in the official statistics. Thus, isolated tissue preparations removed from freshly killed, which form the mainstay of pharmacology practical teaching, would not be reported.

Many alternative approaches to using animals in teaching have been developed (see Gruber and Dewhurst, 2004 for a summary) and undoubtedly these have been successful in replacing or reducing the number of animals used in teaching though the evidence for the scale of the impact these have had is tenuous. Of the range of different alternatives which have been developed probably the most important have been those which make use of new technologies and it is these which will be discussed here.

2 Computer-based alternatives to using animals in teaching

The use of computer-based alternatives to using animals in the teaching of disciplines such as pharmacology and physiology dates back to the early 1980's. Then there were two main approaches to

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development. Some programs were designed to simulate an animal preparation, such as an isolated piece of intestine from a guinea pig, or a perfused heart from a rabbit, and used a mathematical algorithm which predicted, based on known data, how the tissue would respond to drugs or drug combinations, and factors such as electrical stimuli. This type of program encouraged learning by exploration - students would have to select drugs/drug combinations, select doses and routes of administration and, in effect, design the experiments they wished to conduct - and was best suited to a learning environment in which a tutor was present to guide the students. Another approach was to create a tutorial program around data sets derived from real experiments which had been designed by a knowledgeable tutor well acquainted with how a particular animal preparation could be used to teach major principles and factual knowledge. This second approach resulted in programs which could be used independent of tutor support though often learning would be enhanced by the presence of a tutor freed from trouble-shooting technical problems with equipment. Each approach fosters different learning outcomes and both have been demonstrated to be extremely successful in different learning or teaching situations. It is important to recognise that these programs were developed by enthusiastic teachers interested in using technology to enhance the learning experience for their students. Often in achieving this they also replaced animal experiments but this was not the main goal - a fact which has often made it easier to persuade other teachers to adopt them as they are more likely to be convinced by evidence of educational effectiveness than they are by calls to replace animal experiments on ethical grounds. Examples of a large number of computer-based alternatives may be found on the European Centre for Alternatives to animals in higher education (EURCA) website (www.eurca.org).

3 Educational effectiveness

A number of studies have been conducted to investigate how effective these new approaches are in achieving learning outcomes compared to the more traditional laboratory practical class approach which used animals (Clarke, 1987; Dewhurst et al., 1988; Fawver et al., 1990; Guy and Frisby, 1992; Kinzie et al., 1993; Dewhurst et al., 1994; Leathard and Dewhurst, 1995; Hughes, 2001). In the majority of cases these studies demonstrate that the computer-based alternatives are able to achieve many of the learning objectives of practical classes which traditionally use animals with the exception of teaching and practicing both generic and specific laboratory skills (e.g. making up solutions; animal handling; administration of anaesthetics, drugs; surgical procedures such as removal/isolation of a tissue or blood vessel cannulation; using specific pieces of recording equipment; monitoring physiological signs; humane killing). Clearly, if these skills are considered by the teacher to be vitally important, then a computer-based alternative may not fulfill the learning objectives. Equally if these skills are not that important, and in many cases such as medical, pharmacy, and healthcare professional education, they are not, then a computer-based alternative may be more effective in addressing some of the other learning objectives of practical classes (e.g. providing accurate date to enable practice of data handling and presentation skills, communication skills, team working, knowledge acquisition). Computer-based learning resources also have the advantage that they promote interactive, resource-based learning and the development of IT skills. It is probable that only a minority of students will require training in those skills which can only be acquired from a laboratory class using animals. From an institutional perspective this may mean that courses could focus increasingly scarce resources on providing traditional practical classes only for those students whose future careers may demand those skills (e.g. pharmaceutical or academic research). This has started to happen in some courses where practical elements of a course have been focused into optional/elective modules. Even for those students for whom it is deemed necessary to perform practical classes computer-based alternatives may promote a reduction in animal use by better preparing students for the real class (e.g. they can test out study designs, get a feel for the correct doses of drugs and other experimental variables) or enabling a student, whose experiment has failed (not uncommon), to collect the data they will need to meet assessment criteria without killing more animals.

4 Role of the teacher

The importance of the teacher in adopting alternatives cannot be overstressed. It is they who decide - perhaps constrained by factors such as lack of funding, too large class sizes or policies made by their line managers or a professional body - how their discipline, whether it be pharmacology or physiology, will be taught. It is they who must be persuaded to adopt an alternatives approach to a laboratory class and it is important to provide as much support to them as possible. The first step is to make them aware of the existence of alternative approaches which can be achieved through the normal academic dissemination vehicles (conference presentations, journal articles) or via Internet databases several of which already exist (NORINA (http//:oslovets.veths.no/norina/)(Smith and Smith, 1997); AVAR (www.envirolink.org/arrs/avar/alted_db.htm); InterNICHE (www.interniche.org)). Smith and Allen (2005) have produced a comprehensive review of databases to support the use of alternatives.

A workshop, sponsored by ECVAM in 1998 attended by fifteen experts from eight countries involved in developing, using and evaluating animal free models for educational purposes recommended that: "Databases should contain more comprehensive information, for example, contact details, availability, advice on use, target audience and an independent evaluation of the material" (van der Valk et al., 1999). The EURCA (www.eurca.org) project was established to meet these needs and the database provides information rich data on a relatively small number of high quality alternatives including independent reviews, evidence of educational effectiveness, information from teachers who have used a particular resource, and support materials (van der

Valk et al., 2001). More recently, an informal survey of 32 pharmacology teachers from 12 countries (Dewhurst and Hughes, unpublished observations, 2006) revealed that they are most likely to be convinced that an alternative may be useful (in order of importance) by: evidence of educational effectiveness; positive independent reviews; cost, recommendations from colleagues; and objections to animal use by students.

5 Integrating computer-based alternatives into mainstream teaching and learning

To be effective and therefore have an impact on animal use, computer-based alternatives must be integrated into teaching and become part of the assessment process (Dewhurst and Hughes, 1999). Simply making these resources informally available to students over a university network does not work (Markham et al., 1998) as most students have adopted very strategic approaches to learning and their focus is on elements of their course which are assessed and contribute to their final award. As a consequence they will ignore recommendations from teachers to use additional resources unless they are clearly an integral, assessed component of their course.

The process of integration can be time-consuming and many teachers lack the time and sometimes the skills to do this without some assistance. There are ways in which they can be supported and one, which has proved to be successful, is to provide support materials for students to use alongside the computer programs (Hollingsworth et al., 1999, 2001; Norris and Dewhurst, 2002). These support materials may take the form of study guides or workbooks and may include tasks and activities directly related to the computer program and self-assessment questions. If teachers can be encouraged to develop these themselves then, through that process, they acquire some ownership of the teaching materials and this in turn will contribute to their successful integration. This strategy also partly overcomes the resistance of teachers to using third-party resources – the so-called "not-invented-here syndrome".

6 Limitations of current computer-based alternatives

As stated earlier most of the alternatives currently available were developed over a decade ago (pre-Internet) by enthusiastic teachers to enhance their own teaching. Making them available to other teachers was not a major consideration. They thus present a personal view of how a particular animal preparation may be used to teach a particular aspect of pharmacology or physiology. Typically the teacher decides on which experiments to include, which drugs and experimental parameters, how much background information to provide, which self-assessments to include etc. Naturally the computer program they develop to replace a particular laboratory practical will be broadly based on how they used to run the practical class. Undoubtedly their approach will not be the same as that of other teachers and consequently the compute program will not meet all of the needs of all teachers. In many cases these teachers will reject using an existing alternative simply because it does not meet their needs completely and continue to use the laboratory practical which they are familiar with.

Most of the computer programs were initially developed using specific programming languages (e.g. Basic, C, C++) or commercially-available authoring tools (e.g. Authorware©, Director© (Macromedia), and Toolbook© (Asymetrix). In some cases the content expert (teacher) was also the programmer, in others a content expert would work with a courseware developer proficient in the use of authoring programs.

The end result of the development process was a compiled executable (.exe) program in which all of the learning and media assets (text, images, graphics, animations, video, audio, self-assessment questions), the sequencing and learning design were intrinsically linked to the delivery platform or runtime engine. They were usually delivered on floppy disk or CD-ROM such that they could be made available to students over university local area networks (intranets or LANs). The programs were not editable, unless the user had access to the source code and the programming knowledge needed to modify the code, and they could not be delivered over the Internet. In addition technological changes to the delivery platforms underpinning the delivery of the programs (such as the move from DOS to Windows, from 16 bit to 32 bit processing and from VGA to XGA screen resolutions) made it increasingly difficult to use the programs, the only solution being to rewrite them for the new delivery platform, an expensive and time-consuming business. Since the educational content is intrinsically linked to the technologies used to develop and deliver the programs, as the latter become obsolete then the content and pedagogical design is also lost.

A key factor in successful integration of computer-based alternatives into teaching is ownership - teachers are much more likely to use resources they have developed themselves rather than third party resources. As mentioned earlier this may be achieved by a teacher developing "wrap-around" support resources to accompany a third-party computer program but in many ways it would be much better if teachers were able to modify the content or pedagogical approach of the program themselves.

A project (RECAL www.recal.mvm.ed.ac.uk/) which aims to preserve the educational value of these programs in the face of rapidly changing delivery technologies, and propose a new approach to developing programs of this type in the future, is underway in Edinburgh.

7 A new approach to the development and delivery of computer-based alternatives?

The RECAL project has two main goals: preserving the educational content and design of existing computer-based alternatives enabling them to be used with new technological delivery platforms; and providing a different, learning object approach to creating new programs which will prevent problems of obsolescence in the face of rapidly changing technologies. The computer-based alternatives on which the project is focusing is a series of programs developed by the author and now marketed through Sheffield BioScience Programs (www.

sheffbp.co.uk). The approach is to enable more effective management of the component learning and information assets (text, images, animations, self-assessments, video and audio), provide teachers with easy-to-use authoring templates to enable them to build their own resources from these assets, and build future-proofed delivery engines compatible with delivery over the Internet, CDROM or even via PDAs (Personal Digital Assistants)/Smartphones.

The process combines new web-based multimedia technologies such as Macromedia Flash® to develop the content with the use of XML and is based on common learning technology standards and specifications. The system architecture is built around a number of separate components: the run-time engine (currently Flash®); the text (XHTMLhtml files) and media assets (images (.jpg), animations (.swf), video (Flash® Video .flv), audio (Flash® audio .fla) which are stored on a web-server; and the XML parameter files describing the educational sequencing, each of which can be modified independently of the others. When the user starts the program these components are assembled and presented dynamically: the runtime engine (currently the project is using Flash®) looks for the XML parameter file and, finding it, loads the instructions and content specified in the XML. Some of these specifications are URL pointers to external resources such as images, animations, data traces, text and questions which are dynamically loaded in to the runtime program as well. Any one of the components is able to be changed independently of any of the others – images or text may be added or edited, sections of the program can be extended, the program could be translated into any number of different languages or a different runtime engine could be used. In these situations changes to the XML file would point at a different set of text and media assets as defined by the teacher to meet local needs. The capacity to edit existing programs will greatly increase their flexibility: teachers will be able to easily modify the program e.g. reorganise the sequence; add/remove sections, images, text, or questions; change experimental variables such as drug dose, drug names or electrical stimulation parameters; and insert different language versions of the program's text. While Flash® is being used as the runtime engine of choice now, the emergence of a new runtime engine technology in a few years would not create problems as the XML sequence and the media assets are managed separately and these would simply be linked to the new runtime engine. The project has been described in more detail (Ellaway et al., 2004; Dewhurst et al., 2005).

Summary

1. Numerous high-quality computer-based alternatives to using animals in teaching biomedical sciences such as pharmacology and physiology are available at low cost.
2. Many were developed by enthusiastic teachers in the 1990s and, although the content and educational design is still valid, rapid advances in delivery technologies have rendered them increasingly difficult to use and sometimes obsolete with expensive and time-consuming rewrites often being the only solution.
3. Teachers are critical to the adoption of alternatives into mainstream teaching and learning. They need support through awareness raising, provision of teacher-centric information about alternatives and practical help in integrating alternatives into their courses.
4. New methods for preserving the content and educational design of aging computer-based alternatives are under investigation and undergoing proof-of-concept trials. These have the potential, not only to extend the useful life of these programs but to also improve flexibility of delivery, provide local editing functionality, and offer a different approach to future development and delivery of computer-based resources.

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Correspondence to

Professor David Dewhurst
Assistant Principal (e-learning & e-health)
Director of Learning Technology
College of Medicine & Veterinary Medicine
University of Edinburgh
15 George Square
Edinburgh EH8 9XD, UK
e-mail: david.dewhurst@ed.ac.uk