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A new model for developing computer-based alternatives to using animals in tertiary education

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Abstract
In pharmacology multimedia computer-assisted learning programs (CALs) have proved to be viable educational alternatives to experiments that traditionally use animals. Keeping such programs up-to-date and compatible with an increasing range of delivery platforms is expensive and resource intensive. A new project (RECAL) initiated in 2004 set out to develop a creative solution to this problem.

The key approach was to disaggregate existing CALs into smaller-sized learning objects (LOs) and separate these from the runtime environment enabling teachers to modify programs to suit local curriculum needs, and facilitating reuse and collaboration. This process, which comprises four steps (product research/analysis; data transcription; LO handling; and authoring/LO re-assembly), has now been further developed, streamlined, automated where possible and documented to assist other educational software developers.

To-date nineteen existing CAL programs have been processed, generating approximately 2000 revitalised and meta-tagged LOs stored in a standards-compliant custom built digital repository. Authorised users can freely download and modify LOs (e.g. translate text into different languages) and upload new LOs for sharing and repurposing within the pharmacology academic community. Handing content control, creation and ownership back to the community should ensure sustainability and expansion of the repository.

Keywords: computer-assisted learning, alternatives, CAL, repository, reusability

Introduction

The impact and educational advantages of computer-assisted learning (CAL) programs which simulate experiments in pharmacology and other biomedical science disciplines on animal use in tertiary education is well documented (Gruber & Dewhurst, 2004; Dewhurst, 2006; Knight, 2007). Many, if not most, of these programs were developed in the1990's as multimedia applications and marketed to universities in CD-ROM format for delivery, via institutional server(s), across a local area network (LAN). Most developers at that time used commercial authoring programs (such as ToolBook (Asymetrix), Authorware (Macromedia) and Director (Macromedia)). The end product was a compiled executable file containing all of the learning and media assets (text, images, graphics, animations, video and audio), as well as the sequencing and learning design. The educational content was intrinsically linked to the technologies used to develop and deliver the programs. These technologies have changed rapidly (such as the move from DOS to Windows, from 16 bit to 32 bit processing and from VGA to XGA screen resolutions) and they continue to change. This change process means that, for many of these programs, while the educational content and learning design may still be valid, as the delivery mechanism becomes obsolete then they too will be lost. With the now near ubiquity of the Internet and a shift to more off-campus and student-centred learning in higher education there is increasing demand for students to be able to access learning resources from wherever they are studying over the world wide web.

The usefulness of the alternatives programs in any curriculum will depend on the closeness of fit of the program with the needs of the teacher and their willingness to adopt materials developed elsewhere. Teachers generally do not have the skills nor the time to develop their own CAL programs and because their requirements will be dictated by local circumstances (what types of students, time available, learning objectives) they are unlikely to find a program which meets all of their needs. The anecdotal evidence suggests that although teachers will use third-party materials their willingness to do so would be greatly increased if they had the opportunity to be able to

tailor them to meet their local context of use.

The message for those developing e-learning resources is clear - today's educators require editable, web-based learning materials – properties which are not consistent with the LAN-based multimedia CD-ROMs of the last decade.

The RECAL project (www.RECAL.mvm.ed.ac.uk) set out to develop a practical solution to the technological redundancy problem and to find a solution which would enable teachers, with few technical skills, to carry out local modifications to the e-learning resources so that they better met the specific needs of their curricula.

A proof-of-concept pilot was completed in the autumn of 2003 and the full project, funded by The Lord Dowding Fund, started in 2004. The pilot only involved one CAL program, an English-language version of a program originally developed for DOS, later rewritten for early versions of Windows using Asymetrix ToolBook version 2.0 and redeveloped again in 1998 for later versions of Windows using Macromedia Director.

The process (Ellaway, et al 2004; Dewhurst, et al 2005) was to disaggregate existing CAL programs into their component, smaller-sized, learning objects (LOs). The LOs were separated from the runtime environment enabling each of them to be edited thus facilitating reuse and sharing. RECAL has focussed on a series of computer-based alternatives created by one of the authors (DD) and marketed through Sheffield BioScience Programs, since the source code for many of the programs was available and it avoided any issues of ownership of content (IPR: Intellectual Property Rights). However the approach is generic and could be used with multimedia CAL programs in any discipline.

Materials and methods

Overview

There are several key stages to the RECAL process: disaggregation; learning object management including archiving and cataloguing them in a searchable online repository; developing tools to enable dynamic re-aggregation by teachers with few technical skills.

To effectively demonstrate the RECAL methodology in detail, one particular CAL program: *Rat Blood Pressure* (www.sheffbp.co.uk) has been selected. This highly interactive program simulates a range of experiments to demonstrate the effects of a variety of pharmacological agents/procedures on blood pressure and heart rate of the anaesthetized rat *in vivo*. It is aimed at undergraduates studying pharmacology modules on a range of medical and science courses. Each section combines text, high quality colour graphics, and animation with interactive questions designed to reinforce learning.

First developed in 1996 using Asymetrix ToolBook, this CAL program was intended for distribution over a local area network (LAN). However, due to the nature of the chosen technology, it wasn't long before its underlying technology became out of date and in particular it proved somewhat inflexible when making the inevitable move over to Internet delivery. Furthermore, certain sections of textual and graphical content required deleting, modifying and expanding. For example, the introductory section required updates to the 'UK Home Office licence requirements' that apply to this particular type of laboratory experiment. Without a moderate level of expertise in ToolBook, it is problematic for content authors to make these revisions themselves as the content is effectively locked into the development platform.

Disaggregation

The RECAL disaggregation methodology is a clearly defined four-step process (Fig. 1). It assumes a "moderate to high" level of computer know-how, and whilst some steps have small automated sequences, the majority require a considerable level of human input. The first step is product research and analysis which would include verifying issues of IPR and gathering and collating into file types primary information/data sources both paper and digital. Step 2 is to build a navigation map and for this we

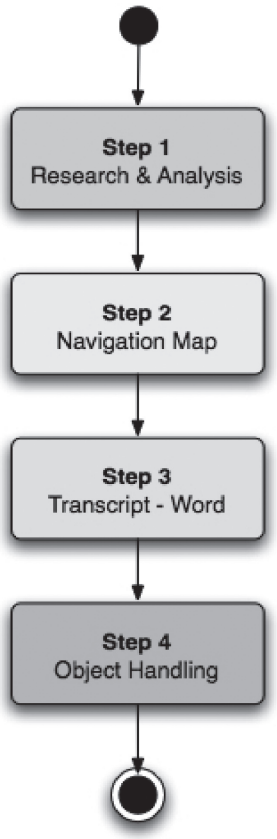

Fig. 1. RECAL Methodology
The RECAL disaggregation methodology is a clearly defined four-step process. Step 1 is product research and analysis; Step 2 is to build a navigation map using VUE; Step 3 is to create a single Microsoft Word document that is a complete transcript of the entire CAL program; Step 4 is LO Handling which involves obtaining, possibly revitalizing and uploading non-text LOs.

use the free Visual Understanding Environment (VUE - http://vue.uit.tufts.edu) which allows users to create a visual representation of the structure of the program and how page/screen links operate. We have also developed a 'Development Time Calculator' (http://www.RECAL.mvm.ed.ac.uk/tools/calculator.asp) which when used in conjunction with the VUE navigation map allows you to calculate an approximate development time. Step 3 is to create a single Microsoft Word document that is a complete transcript of the entire CAL program. This can be carried out manually by extracting all of the text contained/presented in the CAL runtime and any external files and identifying any special characters. This step may be partially automated using specialist 'binary reader' software such as File Juicer (http://echoone.com/filejuicer) and OCR (optical character readers) like Fine Reader (http://finereader.abbyy.com). Step 4 is LO *Handling (Fig. 2)* which involves obtaining, possibly revitalizing and uploading non-text LOs. Often images created many years ago will require improving (revitalising) which, if necessary, could be outsourced to a graphic designer or learning technologist familiar with applications such as Illustrator, Photoshop, or Flash. Sometimes it is better to re-create the image afresh rather than try to improve it.

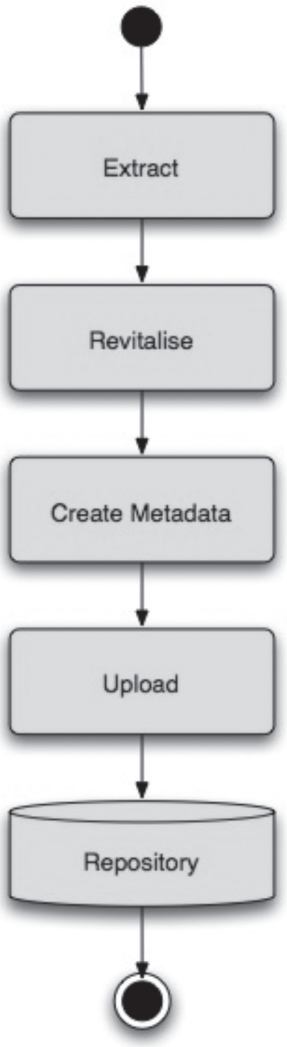

Fig. 2. Object Handling
This stage of the process involves obtaining, possibly revitalizing and uploading non-text LOs using applications such as Illustrator, Photoshop, or Flash. Text and non-text LOs (e.g. blocks of text, an image, an animation, a videoclip) and virtual objects (i.e. a reference to a file located elsewhere) are added into the repository, together with the object specific metadata. Each entry in the proprietary RECAL repository can be exported as an IEEE LOM-compliant XML file (http://ltsc.ieee.org/wg12), allowing for complete interoperability between systems.

Learning Object Management

Text and non-text LOs are first uploaded to an online repository. Local file objects (e.g. blocks of text, an image, an animation, a videoclip) and virtual objects (i.e. a reference to a file located elsewhere are added into the repository, together with the object specific metadata (GUI, title, source/location, descriptor, date, file type, keywords, restrictions on use). Each entry in the proprietary RECAL repository can be exported as an IEEE LOM-compliant XML file (http://ltsc.ieee.org/wg12), allowing for complete interoperability between systems.

Re-aggregation - Labyrinth Authoring (Fig. 3)

The RECAL re-aggregation (LO re-assembly) process uses an in-house developed node-based authoring system (Labyrinth – http://labyrinth.mvm.ed.ac.uk). If the navigation map has been created in VUE then this file can be imported directly into Labyrinth and this creates a navigation shell consisting of nodes (pages) and their navigation linkages. Text from the MS Word transcript may be copied into relevant nodes as can references to LOs (e.g. images, Flash files such as interactive questions, animations) in the repository.

Once this process has been completed the CAL program is now accessible: via a standard web browser; offline via a custom built Flash runtime engine; or as an IMS Content Package which enables upload into other learning management systems. Note that when the finished program is run each screen is created dynamically by drawing down the appropriate LOs from the repository. If Labyrinth or any other XML-based runtime engine becomes obsolete it can be replaced by a new XML engine. The LOs are maintained separately from the runtime engine and each of these can be independently edited. Thus, LOs can be removed and others can be added. For example, new data traces of the effects of novel drugs could be added, text can be translated into any other language, and new tasks, activities, self-assessment questions can be incorporated.

Results and discussion

By adopting principles of communities, standards, objects and reusability RECAL has improved the

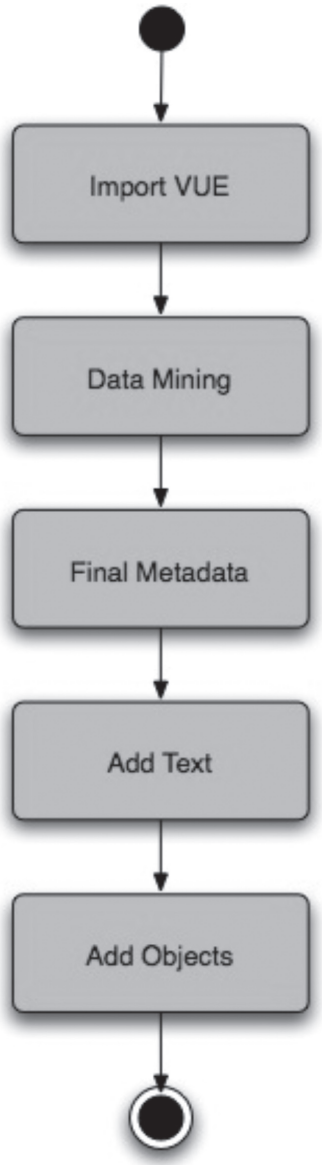

Fig. 3. Labyrinth Authoring
The RECAL re-aggregation process uses an in-house developed node-based authoring system - Labyrinth. VUE files can be imported directly into Labyrinth and this creates a navigation shell consisting of nodes (pages) and their navigation linkages. Text from the MS Word transcript may be copied into relevant nodes as can references to LOs (e.g. images, Flash files such as interactive questions, animations) in the repository.

life span of software alternatives and facilitated their adaptation by teachers to meet local needs. In summary, the following objectives have been achieved:

- a collection of 19 existing CAL resources have been redeveloped and these can be delivered in a variety of formats including the Internet.
- a searchable/browsable repository of learning objects has been created which teachers can use in a variety of ways. The 19 CAL programs have yielded approximately 2000 revitalised and meta-tagged LOs and these are stored in a standards-compliant (e.g. IEEE LOM) custom built digital repository. Authorised users can freely download and modify LOs (e.g. translate text into different languages) and upload new LOs for sharing and repurposing within the academic community.
- easy-to-use authoring tools (such as Labyrinth and Vue) enable non-technical teachers to modify programs - change sequence of LOs, add new LOs, edit existing LOs etc
- development of a sustainable model for educational resource development by separating the content from the run-time engine

Currently we can deliver on CD-ROM: the original program which will run in Adobe Flash, allowing for cross-platform playback and delivery via an Internet browser; all of the learning objects for a particular program; and an IMS compliant 'Content Package' enabling the program to be imported into an institutional VLE.

Handing content control, creation and ownership back to the extended user community should ensure sustainability and expansion of the repository, far better return on investment and a far more sustainable way of working over time.

Future developments will include expanding the number of LOs in the repository by 'processing' further CAL programs, developing an appropriate business model offering: online (Internet) access to all of the programs; teacher access to the online repository of all LOs; and teacher access to the online authoring system (Labyrinth).

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