

Producing a multimedia CD-ROM

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The multimedia capabilities of modern computers promise a rich contribution to medical education, integrating video, animation and graphics as a single courseware package. Using the new generation of design tools, computer-assisted learning material can be successfully created in-house.

INTRODUCTION

For the medical learner/user, gaining familiarity with fundamental procedures and mechanisms is compromised by restrictions on time, location and resources. Although the potential of modern computers to provide alternatives has long been recognized, widespread problems have still to be addressed (Greenhalgh, 2001). A good piece of education software is the tip of a large iceberg, the invisible part comprising needs assessment, design,

knowledge validation, implementation, evaluation and maintenance. The CD-ROM project ongoing at Barts and the London aims to fulfil and surpass the requirements of students of geriatric medicine. This paper will discuss the process of developing a computer-based educational package, using the CD-ROM project as a case study (*Step 1*).

BEFORE STARTING

The developer should be acquainted with the resources at their disposal, in

particular constraints on time and money. In designing learning technology, it is a general principle that users, both direct (students) and indirect (tutors, assessors) should be involved throughout.

Project management software can be extremely useful in devising a programme for large or complex projects, and when the (inevitable) pitfalls and delays occur, the burden of restructuring is considerably lessened.

Evaluators should be identified and approached. If required, approval for the study can take months to obtain, and applications should be made early.

After attending to these preliminary considerations (*Step 2*), the user can begin the needs-assessment phase.

NEEDS ASSESSMENT

To ensure that precious resources are not squandered, it is necessary to establish the user requirements for effective learning and whether computer-assisted learning (CAL) is appropriate in the given domain. This information is crucial to design of the CAL.

WHY COMPUTER-ASSISTED LEARNING?

So what is wrong with traditional paper-based notes or in person tuition? Nothing, but different media have distinct features, as detailed in *Table 1*.

The uptake of computers both in the home and in the workplace has created a climate conducive for computer-aided learning (IT for All, Ms Mira Vogel is Research Fellow and Professor GCJ Bennett is Professor, Academic Department of Health Care of Older People, The Royal London Hospital, London E1 4DG

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STEP 1

The CD-ROM project was conceived with several factors in mind. Electronic vehicles for information are increasingly widespread and knowledge has ceased to be the preserve of the university, which 'no longer provides the guiding dictum to knowledge, nor controls the direction that a client may choose to traverse' (Abeles, 1999). Moreover, students now pay for their higher education and consequently are developing an awareness of their consumer rights. These rights include access to knowledge which is accessible, validated, well structured, current and transparent in its sources.

Medical students are likely to perceive (and have often been constrained to perceive) their task as that of learning large amounts of facts by rote to regurgitate at exam time. They are consequently under great pressure to abandon an effective, deep, elaborative approach to learning in favour of a superficial approach which commits vast amounts of isolated facts to memory, with poor rates of retention (Coles, 1998). Although problem-based learning addresses this issue, medical students still need support to make their learning experience an active, connected, elaborative process rather than a passive one.

The suite of CD-ROM study guides which will be the outcome of this project aims to offer the 'facts', substantiated by references and reinforced by examples, tests and games. A drill-down approach to knowledge has been adopted, and users who wish to do so will be able to access layers of information in increasing detail. The package will be available over the school Intranet and in CD-ROM format.

STEP 2

A management committee, including clinical, financial, educational and student representatives, was convened at the beginning of the project. Monthly meetings were arranged to discuss progress and future direction of the project. The local ethics committee was approached with a methodology for evaluation.

Before acquiring project management software, a programme was drawn up on a spreadsheet (*Figure 1*). The actual course of the project was subsequently recorded over time in a separate workbook as a comparison to the original programme.

	2000					2001				
	27Nov - 3Dec	4Dec - 10Dec	11Dec - 17Dec	18Dec - 24Dec	25Dec - 31Dec	1Jan - 7Jan	8Jan - 14Jan	15Jan - 21Jan	22Jan - 28Jan	29Jan - 4Feb
validate medical knowledge										
literature search										
identify extra material										
structure content										
collect extra material										
evaluate structure										
design interface										
implement interface skeleton										
evaluate interface										
feedback										
1st implementation										
present 1st implementation										
structure evaluation										
present evaluation structure										
(ethics committee application)										
recruit student evaluators										
recruit nurse evaluators										
recruit lay evaluators										
1st evaluation										
implement feedback										
(2nd evaluation)										
go live										

Figure 1. A project programme using Microsoft Excel.

1999), should it be required. CAL is likely to be useful in situations where:

- Target users have demonstrated aptitude with information technology
- Restrictions exist on traditional communication media
- The knowledge base changes rapidly
- Learners/users operate at different paces
- Learners/users have diverse needs
- Learners/users are based in diverse locations.

If a need for CAL is established, the second phase of needs assessment — requirements gathering — can begin (Step 3).

REQUIREMENTS GATHERING

Requirements can be considered in three categories (Preece et al, 1994):

- Functional requirements specify what the joint system of the human and the computer must achieve
- Data requirements specify the structure and data required
- Usability requirements formulate targets for user performance and satisfaction.

At this early stage, ambiguity, omissions or unfeasible requirements should be forced into the fore. The developer may have to use several techniques to expose these, including interviews, observation and surveys. Basic prototypes of the end product are useful at this stage, stimulating the

imagination and providing an anchor for speculation (Step 4).

After requirements have been identified, the project moves into the design phase.

DESIGN

There are three main threads to the design phase:

TABLE 1. Comparison of features of three different learning media

Features	Paper-based	In person	Computer-based
Portable	✓	x	(✓)
Interactive	x	(✓)	✓
Multimedia	(✓)	(✓)	✓
Self-paced	✓	x	✓
Self-directed	✓	x	✓
Searchable	(✓)	(✓)	✓
Non-linear	x	x	✓
No aptitude required	✓	✓	x
Query potential	x	✓	x

x=no; ✓=yes; (✓)=limited

STEP 3

Students of geriatric medicine in the school study a large number of subjects in a short period of time. Needs were identified for:

- Material to supplement modules restricted by lack of staff, time and money
- A more interactive element to enliven the 'drier' material
- Different strata of detail
- Easily maintainable and updateable material.

Consequently, the aims of the CD-ROM project were:

- To signpost and deliver access to information in more detail for motivated students
- To make the learning experience involved and active
- To maximize resources
- To facilitate maintenance of the knowledge.

The study guides are intended to provide an extra learning media in line with advances in technology and extend student learning options.

STEP 4

Of all 239 first and second year medical students, 63% responded to a survey exploring perception of their IT ability, attitude towards learning with computers, access to a computer and their experiences with the existing computer-based facilities in the school. The response indicated that students were satisfied with the platform for computer-aided learning and that most were of intermediate, competent or advanced IT aptitude. A large proportion had unrestricted access to computers other than those provided by the university. The majority was using material provided on the school network for between 1 and 5 hours per week. Most thought that they would be very likely to use a computer-based package covering core material from their curriculum and extra complementary or multimedia material.

- Layout design, concerned with the interface — the way users will interact with the knowledge
- Physical design, the architecture or structure of the CAL project. This is how the information is physically stored and affects the way in which it can be accessed by users and maintained by developers
- Knowledge structure: the order and manner of presenting the knowledge.
- A negative contrast (dark colours on a light screen) provides higher luminance and increased readability
- Approximately 8% of males and 1% of females are colour blind
- Visual symbols are easier to process than text and can also relieve a monotonous screen of text
- Lines of text should be between 58 and 132 mm in length. Word shape clues should be preserved by using a clear, lower-case font.

Layout design

Layout design is concerned with the interface between user and content. Users expect to be able to manipulate knowledge directly and intuitively, based on:

- Assimilated knowledge of the outside world
- Conventions established within the package itself.

For this reason, any metaphor which is used in the interface should be consistent with the culture of the target user and internally consistent throughout the CAL package. For example, the question mark icon, which is used throughout the guide to denote study guide questions, is intuitive to most Western users. Revision is a harder concept to depict. The spectacles icon, although less intuitive, exploits the 'vision' of 'revision'. Designers of new software tend to take advantage of these established conventions. Where icons are more obscure, it is particularly important to use them consistently and exclusively throughout the guide to signal the same type of information.

At the design stage, the ergonomics of the interface should be considered. Some key points to consider are (Dix et al, 1993):

It is a good idea to solicit feedback while developing the interface, since it is often inconvenient to make changes at a later stage.

Physical design

This is the architecture or structure of the CAL package; how it has been programmed to store and present the knowledge that it contains (*Step 5*). All computer systems should use an architecture that is:

- Extendable: it should be easy to seamlessly append extra material
 - Maintainable and updateable: it should be easy to implement changes
- Today's prevalent interactive computing environment is known as WIMP because it uses windows, icons, menus and pointers. A user opens an application in a window, which can be resized, minimized or closed. Interaction with this window and its content is achieved through icons and

STEP 5

The design of the study guide interface (*Figure 2*) incorporates a sidebar menu (or table of contents) in a separate frame. This means that the menu remains visible at all times. The menu contains three icons for access to search, home (the navigational hub of the guide) and help pages, including a user manual. The menu situated below these icons is arranged as a hierarchical tree menu, a well-established convention, an example of which can be found in Microsoft's file management program Windows Explorer. The menu can be expanded or contracted to show or hide sub-sections. Each menu item is a hyperlink, which signals its interactivity by changing its appearance when the mouse pointer is passed over it. Clicking on a menu item instantly loads the section with which the hyperlink is associated, replacing what was previously on screen. Hypertext is intended to allow navigation through different sections in a non-linear way with a minimum number of mouse clicks.

A decision was taken to prioritize usability over appearance, which resulted in sacrificing some control over the position of elements on the screen. Different users with different specifications and settings for their machines can have very different experiences of the same site. For example, screen size can vary by several inches, and this must be considered when specifying the size of components, such as graphics and text. Where possible, sizes within the interface have been specified in relative terms, allowing the user freedom to adjust different elements to suit his or her eyesight or screen size. The three frames which make up each page can be resized by clicking and dragging their borders, while most web browsers allow users to specify the size of the text, assuming the designer has not disabled this option. Images, used extensively to provide easily processed visual clues, are problematic because they cannot be resized. However, while hovering on these images, a label appears. The template for the site has been approved for accessibility by browsers for the blind or partially sighted by Bobby v3.2 (Cast, 2000), a freely available program which checks any submitted source code for elements which could stymie audio browsers and which offers relevant advice to rectify problems.

The knowledge in the guide is arranged in pages that can be navigated using the menu, the map or the search engine. Clickable icons, appearing to the right of the top-level information, signal where users can drill down for extra knowledge. Different icons denote different types of knowledge ('revision' and 'valuable information' are shown in *Figure 2*). Questions, indicated by the question mark icon, are also signalled throughout the guide. Users also have instantaneous access to glossary definitions by pointing the mouse pointer over coloured words.

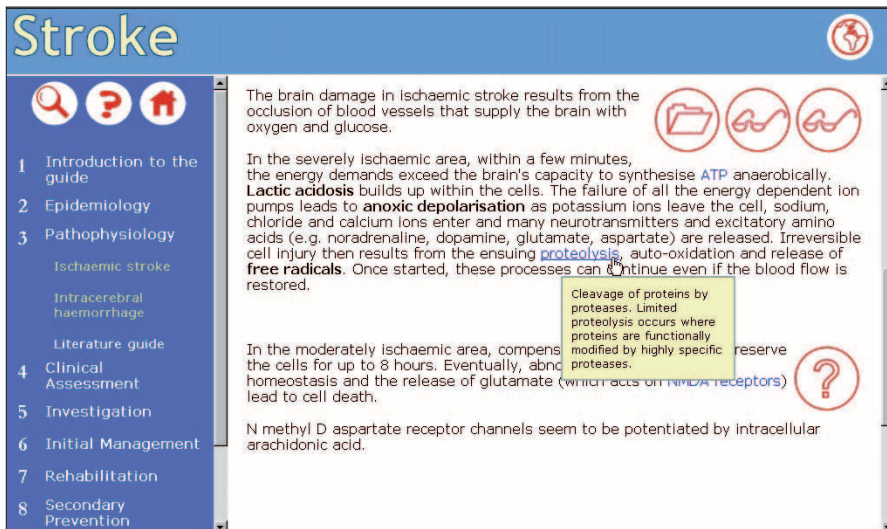


Figure 2. Study guide interface.

menus. Icons are pictorial representations of objects and concepts (Figure 3), which are more easily processed than text. They are often realistic but can also be highly stylised, involving lateral thinking or puns.

Menus offer visual reminders about choices of operations. They can pull down, pop up or remain constantly visible. A menu choice is selected using the last component of the

WIMP interface — the pointer. The pointer, traditionally an arrow, is controlled with an input device, such as a mouse or trackball. In the quest for the intuitive interface, pointers are beginning to give way to technology like touch screens and mouse pens. Advances in artificial intelligence have harnessed brain wave fluctuations to control an external environment with the power of thought (Lusted and Knapp, 1996).



Figure 3. Icons (Icon Bazaar, 2001).

Knowledge structure

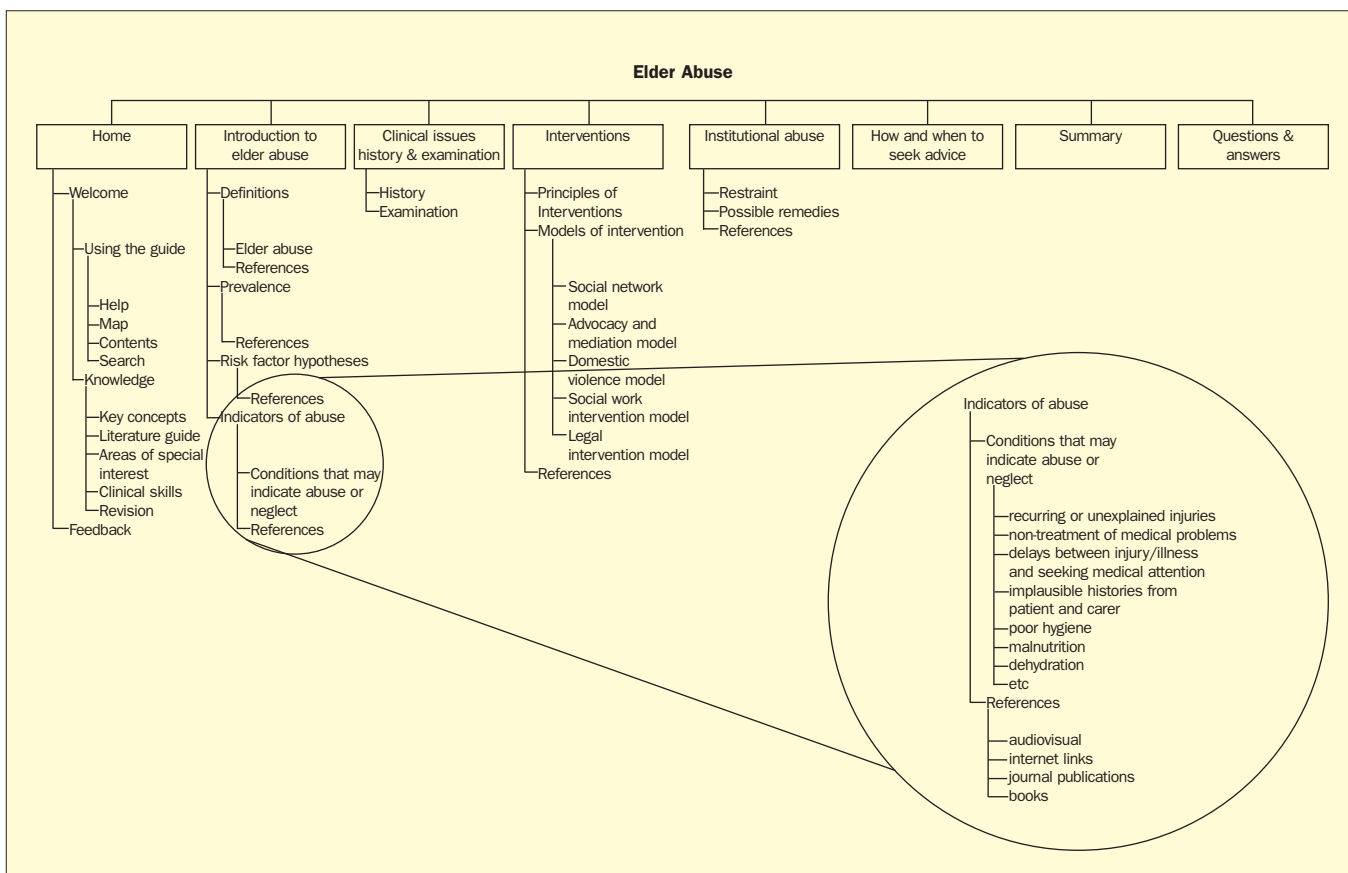
Knowledge should be structured appropriately by experts. It is important to consider future maintenance during this process. Human memory is notoriously unreliable, and the original developer will not necessarily carry out future maintenance. For this reason, it is important to document the structure of the knowledge. Concept maps, such as the one in Figure 4, are one way of representing knowledge structures.

With this method, it is possible to drill down, generating further maps, until one can account for the entire content.

KNOWLEDGE VALIDATION

As medical knowledge expands, existing bodies of knowledge require rigorous maintenance. The developer should

Figure 4. Concept map using Microsoft Organization Chart 2.00.



STEP 6

The expert authors of the original study guides are extremely busy and dispersed between Belfast and London. It was therefore necessary to streamline the knowledge validation process as far as possible, and to this end a meeting with each author was arranged to discuss their vision for implementing the guide and to hand out a pack containing:

- A prototype CAL version of their study guide on CD-ROM
- Their original paper-based guide
- A copy of the guide on floppy disk
- Guidelines for review and amendment.

A prototype of the CAL package is included to stimulate interest and imagination. It is suggested that the paper guide be used for review and changes or extra material be inserted in red font on the digital document using a word processing package. Additionally, a deadline for validation is negotiated at the time of handing out the review pack so that the project programme can be adjusted accordingly. Authors are asked to suggest a best-before date for the next review, which should reflect the pace of change in their domain.

be satisfied that the material is current, complete and accurate (*Step 6*).

At this stage, copyright and confidentiality issues should be resolved.

MULTIMEDIA MATERIAL

Well-produced multimedia material — using sound and moving images — in medical education is far richer learning material than text or static images alone. Its production is highly technical; awareness of a range of issues, from the importance of file sizes to how the multimedia material can be integrated, is crucial.

Producing multimedia material is also time-consuming and expensive. For this reason, developers must examine the relative merits of outsourcing and inhouse production. Outsourced multimedia is usually high quality, stylish, reliable and expensive. The professionals involved in its production usually have a good awareness of technical issues. However, there are disadvantages to outsourcing, including a potential loss of control of the final product and its minutiae. On the other hand, producing multimedia inhouse involves a large initial investment in terms of money and in terms of time spent practising with hardware and software. It also involves a continuing investment of time spent recording and editing the product.

However, inhouse developers bring expertise and awareness of subtleties of the subject matter which rarely exist outside. Additionally, the process of planning, scheduling and recording can

be less protracted where the multimedia developer is on site.

Whether inhouse or outsourced, a planning stage is necessary for animation, video and audio recording. In common with film-making, this usually involves ‘storyboarding’, the process which include accounting for each ‘take’ and outlining changes of focus or camera angle. If a scenario with human contributors is planned, it is necessary to script and rehearse any dialogue and activity.

The type of file format selected for the material affects how the user can access the multimedia. For example, where animations have been developed using certain tools, the user requires a separate program (known as a plug-in) to view the animation. This could be included with the CAL package, but the user may resent having to install it. In some circumstances, multimedia files can also ‘stand alone’ without needing to be interpreted by a separate program and this is the most desirable scenario.

Although time consuming and expensive to produce, well-executed multimedia material is extremely

engaging and offers a real opportunity for self-paced, self-directed learning without the traditional restrictions of time and space. In this respect, it undeniably asserts the worth of CAL.

TOOLS FOR IMPLEMENTATION

The CD-ROM is a well-established medium with a large data capacity. CD-ROM drives are available in the vast majority of computers purchased in the last 5 years, an advantage which, at the time of writing, is not true of other digital distribution media. Some hybrid media have successfully integrated CD-ROM with network technology. Mattheos et al (2000) achieved a seamless package using video material on CD-ROM to compensate for slow connection speeds over a network. Consequently, they preserved the ease of update, low costs and scalability offered by networks, and at the same time were able to overcome specific problems which their network experienced with large files.

The choice of authoring tool depends on the content and intended use of the end product. Demonstration versions of many tools are available free for download over the Internet and can be sampled before purchase. It is often difficult to evaluate the relative merits of several options, and one way of overcoming this is to rapidly prototype a representative part of the CAL package using the shortlisted tools. The most appropriate development tool should then emerge from this process.

As well as providing a convenient environment for development (*Step 7*), the selected tool should be capable of rendering an end product that is:

- Extendable — it should be easy to append information
- Maintainable — it should remain easy to manipulate the content

STEP 7

Since the study guides were intended for distribution on the school Intranet, as well as on CD-ROM, html (including its recent incarnations such as dhtml and xml), was chosen as the underlying language of the study guide.

Macromedia Dreamweaver UltraDev was selected as a development environment because it offers an intuitive WYSIWYG (what you see is what you get) interface and, importantly, ready access to the underlying source code should the need arise, which is not true of all authoring tools. Allaire Homesite 4.0 was also used.

- Transparent — the methods for achieving different aspects should be clear
- Able to stand alone — it does not require any special software or hardware to run
- Scalable — it should be accessible from different platforms.

It is important to test each stage of development in its intended environment since variations in hardware — sizes and different resolutions of screens, varying processing speeds and varying graphics and sound capabilities — can bring about very different viewing experiences.

EVALUATION

In a modern educational package, there are many different aspects to evaluate, including:

- Ease of navigation
- Effectiveness of communication
- Learning outcomes
- General appeal
- Costs vs benefits.

Evaluation of navigation should happen at an early stage. Where problems are identified, it is usual for the evaluation process to be iterated until a reasonable level of satisfaction is reached (*Step 8*).

MAINTENANCE

When distributing knowledge that is rapidly changing, it is good practice to include a publishing date and a best before date. This is especially important in the case of CD-ROMs, where control over the information and its use is lost as soon as it passes from developer to user.

Since user feedback should be encouraged, full contact details for maintenance should be included.

All information on the master copy of the package must remain current, complete and accurate, and changes should be logged. With access to the Internet and e-mail, this burden can be considerable lightened with:

- E-mail alerts of current tables of contents from relevant publications
- Electronic discussion lists or newsgroups
- Logged literature searches.

Contact details of CD-ROM users should be kept so that updates can be

communicated. An address of a website where bulletins and alerts can be posted should be included on the CD-ROM.

CONCLUSIONS

The development of a CAL package is a continuous, iterative process drawing on several disciplines. Success requires close attention to the needs of target group users, a dynamic approach which can anticipate and accommodate change, and stakeholder involvement at each stage. Although, evaluation and distribution of the final product are to come, there are early indications that applying this formula to this CD-ROM project will result in a versatile and well-received contribution to the spectrum of media at a learner's disposal. **HM**

CD-ROM project advisory panel:

Professor Gerry Bennett (Barts and the London — Academic Department of Older People)
 Dr Richard Bull (Homerton Hospital — Consultant Dermatologist)
 Dr John Davies (Queen Mary College — Research Support and Business Office)
 Dr Patrick Gompertz (Geriatric Office)
 Professor Sheila Hillier (Queen Mary College — Head of Division, Community Sciences)

Ms Alison Hopkins (Royal London Hospital, Mile End — Clinical Nurse Specialist)
 Ms Valerie Joliffe (Bamboo Investments Plc)
 Professor Robert Stout (Queen's University Belfast — Department of Geriatric Medicine)
 Dr Diana Wood (Endocrinologist and Senior Lecturer in Outpatient Medicine — Royal London Hospital, Whitechapel)

- Abeles TP (1999) The academy in a wired world. In: Thorne M, ed. *Universities in the Future*. DTI, London
- Cast (2000) Bobby v3.2: The Website Validator for Disability Access and Browser Compatibility. Available at: <http://www.cast.org/bobby/> accessed 25 January 2001
- Coles C (1998) How students learn: the process of learning. In: Jolley B, Rees L, eds. *Medical Education in the Millennium*. OUP, Oxford: 63–82
- Dix A, Finlay J, Abowd G, Beale R (1993) *Human Computer Interaction*. 2nd edn. Prentice Hall, London
- Greenhalgh T (2001) Computer assisted learning in undergraduate medical education. *Br Med J* **322**: 40–4
- Icon Bazaar (2001) Available at: <http://www.iconbazaar.com/computer/> accessed 23 January 2001
- IT for All (1999) *Is IT for All?* DTI, London
- Lusted HS, Knapp RB (1996) Controlling computers with neural signals. *Sci Am* **275**(4): 82–7
- Mattheos N, Nattestad A, Attstrom R (2000) Local CD-ROM in interaction with HTML documents over the Internet. *Eur J Dent Educ* **4**: 124–7
- Preece J, Rogers Y, Benyon D et al (1994) *Human-computer Interaction*. Addison Wesley, Harlow

STEP 8

Recruiting volunteers for the small preliminary evaluation of the study guide interface proved a challenge. Initially, posters were placed in the school which invited students to view a template and offer feedback, and appealed to an interest in shaping their own education. Since there was no response to this campaign, first year students were addressed after the last lecture of the day (Wednesday lunchtime) and invited to a nearby room to view the CAL package on a laptop. This approach also failed to attract any volunteer evaluators, although it was stressed that the session would last no longer than 10 minutes.

As a result, evaluation involves distributing the CAL study guide to fourth year students as they rotate through the department. Pre- and post-tests have been used to gauge baseline knowledge and subsequent changes. This methodology is subject to several confounding factors — CAL is notoriously difficult to evaluate and, where there is a traditional system already in use, evaluation becomes an ethical minefield. Qualitative data is being collected using pre- and post-questionnaires exploring attitudes to the package and to learning with computers in general. Logbooks are also used to identify patterns of use. The evaluation, which is ongoing, is an iterative process, which continues to inform the early stages of development.

KEY POINTS

- There is a healthy climate to support computer-assisted learning in the home and in institutions.
- A need for computer-assisted learning should be established before beginning the project.
- A number of authoring tools are available to facilitate in-house production by developers with a working knowledge of computers.
- Stakeholders should be involved at all stages of development.
- Knowledge should be validated and structured by experts.
- An infrastructure should be developed to maintain the knowledge and alert users to changes.