Review
Computer-assisted learning in dentistry
A view from the UK
P. Grigg*, C.D. Stephens
Division of Child Dental Health, University of Bristol Dental School, Lower Maudlin Street, Bristol BS1 2LY, UK
Received 28 April 1997; revised 4 July 1997; accepted 1 November 1997

Abstract

Objectives. The objectives of this paper are to review the development and impact of computer-assisted learning (CAL) in dentistry with emphasis on the UK.

Data sources. This is a wide ranging review of dental, medical and technical literature.

Study selection. An attempt has been made to evaluate present knowledge in an objective manner and to make some prediction as to the future development and use of computer-based teaching methods in dentistry.

Conclusions. The introduction of computers as an educational tool in dentistry and the provision of CAL is having an impact not only on how dentists are trained but also on the skills they will need to acquire in the future to keep pace with this new technology. It is suggested that there is a great potential for computer-based continuing professional education for dental practitioners, and that the Internet will provide access to such material. © 1998 Elsevier Science Ltd. All rights reserved.

Keywords: Computer-assisted learning; Informatics; Dental education; Education technology

1. Introduction

The first computers were developed during the Second World War. In the United Kingdom, Colossus—built by the Post Office Research Laboratories in 1943—was used at Bletchley Park to assist in the breaking of the German Lorenz (Enigma) code. Two years later in America, Eniac (electronic numerical integrator and computer) was being used to compute artillery firing tables for the American army. These were the first members of the first generation of computers.

As technology advanced, so the speed, memory size and storage capacity of computers increased, but it took almost 30 years before some mainframe third-generation computers were used to support computer-assisted learning (CAL). It has really only been in the last ten years with the appearance of cheap personal computers that CAL in dentistry has become a reality.

2. Computers in medical and dental education

The use of computers as a learning tool in the medical and dental fields dates back to the early 1970s. In 1971 the Dental Science Study Centre at the University of Kentucky provided CAL as part of an experimental flexible dental curriculum [1], whilst CAL was introduced into the medical curriculum for General Practice at Glasgow University in 1975 [2]. Initially these huge computers were centrally located, with telephone lines linking remote terminals. This type of system was expensive both in terms of capital and running costs and there were significant problems gaining access when several users wanted to run a program using the central processing unit. The introduction of desk-top microcomputers enabled the deployment of CAL at relatively low cost [2,3], and by the late 1970s the first packages were available for such machines for the teaching of undergraduate anaesthetics [4], and for self-assessment by medical postgraduates [5]. However the real increase in the use of microcomputers in dental education came in the years following the introduction of the IBM PC (personal computer) in August 1981. By this time an editorial in the British
Dental Journal in 1981 [6] was speaking optimistically of the role of computers in dental education and dental practice, reiterating the message of the Nuffield Committee of Enquiry into Dental Education whose report had been published two months earlier. Seen from a perspective of the late 1990s these sentiments were correct, if somewhat optimistic. At this time the basic IBM machine had no hard drive and ran off a low density ‘5½’ floppy disk drive with only a monochrome monitor limited to text-only 80 column display [7].

3. The origins of CAL in dentistry in the UK

By this time, however, universities were entering the harsher era of reduced higher education funding, which was heralded by the famous valedictory address of Sir Peter Swinnerton-Dyer, the outgoing vice-chancellor of Cambridge University delivered on the 1st October 1981 (The Times, Friday 2nd October). In this climate, which was to be followed by a 10% reduction in staffing of UK dental schools, computers and other audio-visual aids were seen as a possible means of supporting education needs with declining human resources. At this stage a number of simple programs were already available for the dental undergraduate. The first of these was reported by Stephens and Dowell [8], in a paper which showed that dental undergraduates welcomed computer-assisted instruction. In 1984, Luffingham [9] described another orthodontic CAL package. This used an Apple II 48K microcomputer to control a videotape recorder and allowed users to answer simple multiple-choice questions (MCQs) about the material presented on the tape [9]. This showed that teaching by this medium was an effective substitute for conventional teaching of factual information. Since then, there have been many advances in both computer technology and in the ways in which material is put together and presented to users. Machines are now much faster, high definition colour screens are now standard as are CD-ROM drives and hard disk space is measured in gigabytes. As a consequence, moving images and stereo sound can be easily incorporated into teaching sequences giving rise to the term ‘multimedia presentations’ although the contribution which such refinements make to the teaching of clinical subjects has yet to be demonstrated.

More important to universities has been the dramatic drop in the cost of computer hardware which has finally realised the aspirations of ten years ago. Instead of being an expensive piece of equipment, computers are now as affordable as a television set and a video recorder.

4. Strengths and weaknesses of CAL

There are a number of ways in which computer-based teaching offers advantages over conventional teaching methods. First, CAL can be carried out at the user’s own pace, rather than dictated by someone else (e.g. a lecturer). The program can be interrupted at any point and repeated as many times as the user requires. Hence computers are not viewed as ‘judgmental’ and users can learn from their mistakes in an unthreatening way (unless the package has been specifically developed for assessment purposes). In addition, there are potential savings, which can be made in teacher time when using CAL based teaching material [10]. Craig and Moreland [11] note that CAL can ‘assist faculty members in improving their instruction and, at the same time, to keep the unit cost of instruction reasonable and constant’. Indeed, one of the pressures to develop CAL in orthodontics subjects was the desire to provide more training when at a time when there were reductions in the numbers of academic staff available to teach this subject [12].

However, there are also a number of disadvantages which need to be taken into account when planning and developing CAL packages in dentistry. Firstly, the attraction of adopting increasingly powerful hardware and the production of innovative software can be time consuming as well as costly. There is a real need to ensure that CAL is motivated by educational goals, rather than by what is possible using the latest technology [13–15]. Longstaffe [16] describes one approach to developing CAL in which the package itself has deliberately been kept simple through the use of a strategy called ‘Modified Socratic Dialogue’ in which students are given access to a series of computer-based questions and answers after attending a lecture on the subject, but before going on to a tutorial. It is ‘modified’, because it is felt that the first-year students using the package would need slightly more direction than that given by Socrates to his students [16].

Secondly, start-up costs can be high. This is not so much in terms of capital costs (20 computers for use by undergraduates cost far less than the annual salary of a clinical lecturer), but more in the time needed for staff to develop the skills needed to effective produce CAL. At first, many hundreds of hours can be spent by the inexperienced teacher in producing a single hour’s worth of rather indifferent material which would be just as effective in written form. In addition, it can take time to see efforts rewarded by appearing in the curriculum [10].

Finally, reading and looking at data on screen is different from using a book etc., so users and producers of teaching material in this form need to develop a different approach in order to use CAL effectively. This need to become familiar with the medium is, in fact, no different to the time which used to be taken to become an effective lecturer or to learn to produce effective videotape. As with videotape, on top of this there is the time taken in producing the material, which can be considerable. But on the positive side it should be emphasised that the ease with which computer-based material can be continually improved updated or modified to take account of local needs means that it is a far wiser investment. Moreover, a few minutes of an expert’s time can transform the efforts of the non-expert and permits very
Table 1
CAL packages available through the Department of Health Section 63 Initiative. Distance Learning Material for General Dental Practitioners, Dental Services Branch, Department of Health, London, October 1996, pp. 3-4.

<table>
<thead>
<tr>
<th>CAL package</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Currently available</td>
<td></td>
</tr>
<tr>
<td>Orthodontic Case Assessment</td>
<td>C. Stephens</td>
</tr>
<tr>
<td>Aspects of Partial Denture Design</td>
<td>J. Davenport and D. Pollard</td>
</tr>
<tr>
<td>Minimal Preparation Resin Retained Bridgework</td>
<td>N. Meredith</td>
</tr>
<tr>
<td>Endodontic, Diagnosis and Management</td>
<td>N. Meredith</td>
</tr>
<tr>
<td>Dentistry for Special Needs Patients</td>
<td>R. Bedi and D. Pollard</td>
</tr>
<tr>
<td>Oral Manifestations of HIV Disease</td>
<td>S. Porter</td>
</tr>
<tr>
<td>Introduction to Occlusion</td>
<td>N. Meredith</td>
</tr>
<tr>
<td>Aspects of Minor Oral Surgery</td>
<td>D. Pollard, I. Matthews and J. Frame</td>
</tr>
<tr>
<td>Safequest (Cross Infection Control)</td>
<td>P. Downes</td>
</tr>
<tr>
<td>New Dentures for Old</td>
<td>N. Jepson</td>
</tr>
<tr>
<td>Under development</td>
<td></td>
</tr>
<tr>
<td>Treatment of Fractured Incisors in Children</td>
<td>J. Nunn</td>
</tr>
<tr>
<td>Problems and Solutions for Anterior Crowns and Veneers</td>
<td>S. Northeast</td>
</tr>
<tr>
<td>Advances in Adhesive Restorative Dentistry</td>
<td>S. Northeast</td>
</tr>
<tr>
<td>Oro-Facial Signs of Child Abuse</td>
<td>R. Welbury</td>
</tr>
<tr>
<td>Endodontics for the Primary Dentition</td>
<td>A. Gould</td>
</tr>
<tr>
<td>Core Skills in Informatics in Dentistry</td>
<td>C. Stephens and P. Grigg</td>
</tr>
<tr>
<td>Pit and Fissure Sealing</td>
<td>P. Rock</td>
</tr>
<tr>
<td>Core Knowledge of Radiography/Radiology.</td>
<td>R. Hobson, A. Adams, D.J. Lovelock and J. Stephenson</td>
</tr>
</tbody>
</table>

professional material to be developed by the students themselves as part of their project work.

CAL has been found to be popular with users, and there is an increasing audience for well chosen material to be produced [10,17–22]. From the teachers’ point of view a 'shareware' approach, such as that encouraged by initiatives such as those of the Department of Health for Postgraduate Dental Education and the Teaching and Learning Technology Programme of the Higher Education Funding Council, can be to the mutual advantage of all. In turn, the availability of teaching software provides more justification for a dental school to make the necessary capital investment in hardware for students and encourages more clinical teachers to become involved in producing this form of teaching material.

5. Does CAL work?

5.1. General educational evidence

In 1991, Kulik and Kulik [23], at Michigan University, carried out a meta-analysis of 254 controlled evaluation studies. They found that CAL usually had a positive effect on students, with scores raised by an average of 0.30 standard deviations, which was coupled with a small but positive change in student attitudes and a substantial reduction in the amount of time required for instruction.

5.2. Evidence in clinical medicine

Jelovsek and Adebonojo [24] of the College of Medicine, E. Tennessee State University, examined 49 ‘clinical’ trials comparing computer-based learning (CBL) with conventional methods of learning. They looked at cognitive outcome, behaviour and learning theory using students, doctors and patients as learners. In performance terms they found that CBL was as good as conventional learning in 98% of the studies, and that CBL showed an improvement between pre-test and post-test scores over conventional methods in 61% of the studies. As far as the time taken to use each method was concerned, they found that generally learners took about the same amount of time to achieve the same performance, though a small number of studies indicated that more time was taken to achieve a better overall performance (because of enhanced motivation or better opportunity), or even that CBL required much less time to achieve the same performance.

Gathy et al. [25], at Leuven University in Belgium, used a simple, linear CAL tutorial in histopathology with two groups of students, who had been split, according to pre-test scores, into a weak group and a strong group. They found that those students in the weaker group showed a significant improvement in their scores compared to the stronger group, and that nearly all the students expressed a preference for using the computer-based material.

Brown and Carlson [26], at the Jefferson Medical College, PA, compared a CAL package on the early diagnosis of substance abuse, comparing it to work in the treatment centre, a conference on its own and a series of lectures coupled with a visit to the centre. Their preliminary findings indicated that learning with CAL was at least equal to immersion experience, and significantly superior to other more formal methods of teaching.
Indirect Retention - page 1 of 16

Saddle movement

This page is concerned with the effect of sticky foods on a free-end saddle during mastication.

As the teeth separate during mastication sticky foods will tend to pull the denture in an occlusal direction.

First, observe four possible types of denture movement by clicking on the blue buttons opposite.

Then indicate which one of the four movements is most likely to result from the effect of the sticky food by clicking on a, b, c or d.

Demonstrate:

- movement a.
- movement b.
- movement c.
- movement d.

Most likely movement: □ a □ b □ c □ d

Fig. 1. A screen grab of aspects of partial denture design by Pollard and Davenport [20].

6. What is currently available in the UK

There is a wide variation in the types of CAL packages available, both in subject matter covered and in the way it is presented. Advances in computer technology have led us to the possibility of ‘virtual reality’ surgeries, in which computer users can find out what happens if they decide to use a ‘not-recommended’ treatment option, as opposed to current preferred practice, and in future years this type of CAL package should be readily available for use as a learning tool in dentistry [27].

6.1. Electronic books

In an electronic book, the authors take a standard dental textbook and convert it into an electronic version. One example of this is given by Pollard and Davenport [20] who took a book on removable partial denture design [28] and converted it into a CAL format (Fig. 1).

Despite being based on a book, an evaluation indicated that CAL had an advantage over the book in that users were able to hold a ‘dialogue’ with the package through the use of activities such as the manipulation of on-screen graphics; however, as discussed in the next section, the development of this type of program takes much longer than setting up a basic ‘question and answer’ tutorial. However, there are many potential advantages to being able to set up software of this nature, as long as the developers bear in mind what it is they are setting out to achieve. The facilities available on modern computers can all too often encourage programmers to concentrate on producing intricate pieces of software in which the purpose of the package appears to be to demonstrate the ability of the software development team as opposed to providing a facility which can enrich a student’s learning experience.

In restorative dentistry, the University of Sheffield has developed a CAL package covering ‘Dental Caries and Inflammatory Periodontal Diseases’ in order to encourage self-learning skills and develop IT skills amongst students, and to replace passive learning acquired through lectures with the interactive learning that should be encouraged through the use of CAL [10]. They found that the CAL packages developed helped lessen the load on academic staff caused by increasing student numbers and research commitments, and plan to use CAL to replace some teaching sessions, noting that ‘CAL packages were not intended to replace the teaching of this course, but to be used as a teaching tool to complement the more traditional lecture-based methods’ [10].

6.2. Image libraries with explanatory notes

Electronic image libraries are an exact parallel of the ‘Colour Atlas’, which has become very popular in recent years. The quality of images are now acceptable and they are relatively instantaneously retrievable and link together in a way that a traditional book is unable to provide. Sometimes delivered on CD, but also available over the Internet, image libraries give access to a vast number of dental and medical images. An example of this is at DERWeb (Dental Education Resources on the Web). DERWeb is an Internet site based at Sheffield (http://www.derweb.ac.uk/derweb.html) that also provides a variety of information about teaching material in dentistry. A similar, medical
Fig. 2. A screen grab of orthodontic case assessments.

site is MIDRIB, a project being undertaken by staff at St George’s Hospital Medical School London and the University of Bristol in collaboration with the Wellcome Trust (http://www.midrib.ac.uk). The aim of this site is to create, maintain and deliver a comprehensive collection of medical images in digital form for use in teaching and research. In the future, this approach is likely to offer the prospect of access to interactive three-dimensional material.

6.3. Hypertext

In a hypertext tutorial, users are able to follow a different route through the tutorial depending on the nature of the question they want to answer. The hyperlinks within the tutorial allow a user to access relevant images or text or even video clips. Turner and Weerakone [12] describe an example of a hypertext system developed and used at Birmingham Dental Hospital to complement the undergraduate training programme in orthodontics. The system consists of a database of orthodontic information which can be accessed and read in any order. Text screens are linked to numerous graphic images, many of which are interactive. Linked to the provision of this information, is a series of associated questions, which provide a means for student self-assessment, the scores from which give feedback on student performance and the efficacy of teaching methods. A more complex program, which has recently become available, is that on biomechanics in orthodontics by Fiorelli and Nelson available at http://www.ats.it/fiorelli/home.html

6.4. Problem-based learning tutorials

Much of the teaching of clinical problem solving has been undertaken during diagnostic clinics which students attend during the final years of their course. Because of the need to address patients’ problems in a speedy and efficient manner in an increasingly cost-conscious health service, such clinics do not provide the ideal opportunity for student participation. Moreover, recent years have seen a trend which has reduced the number of routine diagnostic problems being seen in dental school teaching clinics. Much of the material now falls well outside the type of problem which a dental graduate would be expected to solve at the primary care level.

As a consequence of this, CAL packages were developed in order to provide this experience by taking students step by step through the questions they need to answer in order to solve routine diagnostic problems. An example of this type of tutorial, developed at Bristol University [17], leads users through a series of questions covering case assessment and treatment planning on particular cases in orthodontics, with detailed feedback relating to the answers given by users (Fig. 2).

Initially a text-based CAL package linked to photographs and models supplied separately, the package now incorporates images on screen and is completely self-contained, with further information being provided by help screens that the user can call up as and when needed to obtain further information about any particular point of interest. The package was developed using a template of questions written by the Education Technology Services at the University of Bristol, using Asymetrix ToolBook authoring package...
Chapter 3: Development of the occlusion

Q1. Gum pads. Which of the following are true?

Click T for True, F for False or D if you Don't know

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) The gum pads are essential for chewing.</td>
<td>T</td>
</tr>
<tr>
<td>b) The lateral sulcus is a groove distal to the crypts of the lateral incisors.</td>
<td>F</td>
</tr>
<tr>
<td>c) The relationship of the upper and lower gum pads is a good predictor of the adult skeletal relationship.</td>
<td>T</td>
</tr>
<tr>
<td>d) The lateral sulci can be used to describe the neonates anterior/posterior arch relationship.</td>
<td>T</td>
</tr>
<tr>
<td>e) The upper and lower gum pads maintain a static relationship as growth occurs.</td>
<td>T</td>
</tr>
<tr>
<td>f) The upper lip frenum is in continuity with the incisive papilla of the gum pads only in children who will later develop a midline diastema.</td>
<td>F</td>
</tr>
</tbody>
</table>

Score Question: 2

Explanation:

(Asymetrix, Seattle, WA, USA) and is an example of a template being produced from a template (Fig. 3).

6.5. Clinical decision support systems

There are a number of ‘Expert Systems’ available in medicine (for example, http://www-UK.hpl.hp.com/people/ewc/list.html). None are in particularly wide-spread use, however the recent move towards evidence based medicine makes it certain that these systems will become increasingly relied upon to provide an up-to-date basis for diagnostic and treatment decisions. In these systems, the computer is ‘taught’ to act as if it is making decisions like a human ‘expert’ [29–32]. Tira et al. [30] note that this ‘will serve the purpose of sharing expertise in clinical judgement,’ whilst Zimmerman et al. [31] feel that ‘this new area of computer technology uses the computer to assist the physician in reaching the correct diagnosis or the most appropriate method of treatment’. In other words, if an expert system is available electronically, either on the user’s own computer system or via the Internet, then it could act as an additional resource for the continuing education and training of dentists [32]. For example, there is an expert telematic system that looks at the quality of radiographs and tells users whether or not their radiographs are adequate for clinical purposes. [33]

7. How is CAL developed?

The problem for clinical teachers with relatively limited computer skills is how to produce CAL material. One of the options available for the development of CAL is to bring in a computer specialist to produce CAL on behalf of subject specialists. Alternatively subject specialists could themselves learn to program the computer. The advantage of this latter approach is that (i) the CAL produced is more ‘customisable’ and (ii) it can be done within any apparent cost. However, the downside is the additional time it takes either for the subject specialist to learn how to program a computer or for the computer programmer to learn enough about the subject to be able to interpret what the subject specialists wants to achieve from the CAL package itself. Many have done this but few clinicians have the time to keep up with the growing possibilities of this fast expanding software.

A compromise option is to use a template. This allows subject specialists to start producing CAL with a minimal amount of knowledge of programming. The advantage of this is that CAL packages can be put together relatively quickly, allowing the specialist to concentrate on the content of the course rather than having to spend time developing the program itself. The disadvantage is that the package is limited by what is available within the template—the CAL package is no longer as ‘customisable’ as if programmed from scratch. Two examples of templates that can be used to develop CAL are the CALScribe and CTICM templates (CTI Centre for Medicine, University of Bristol). Both have been written using the authoring package ToolBook (Asymetrix, Seattle, WA, USA). CALScribe allows subject specialists to put together a tutorial (or a series of tutorials). Each tutorial is in the form of a book, in which users move from page to page, answering questions or reading text, with images incorporated as and where appropriate.
Table 2
Internet Sites of special interest for CAL, and further contact addresses

<table>
<thead>
<tr>
<th>Organisations</th>
<th>British Society for CAL in Dentistry</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DERWeb (Dental Education Resources on the Web) is an Internet site providing a variety of information about both teaching material in dentistry and access to further resources at:</td>
</tr>
<tr>
<td></td>
<td>For details of computer-based dental educational resources</td>
</tr>
<tr>
<td></td>
<td>Dentanet is an Internet forum for the dental community and has details of available CAL programs</td>
</tr>
<tr>
<td></td>
<td>School of Dentistry, The University of Birmingham Examples of CAL for downloading</td>
</tr>
<tr>
<td></td>
<td>Bristol University Dental School Home Page:</td>
</tr>
<tr>
<td></td>
<td>Glasgow University TILT Group in Dentistry:</td>
</tr>
<tr>
<td></td>
<td>United Medical and Dental Schools Home Page:</td>
</tr>
<tr>
<td></td>
<td>A sampler of CAL package in orthodontics, from Butterworth Heinemann OMNI (Organising Medical Network Information), based in Nottingham, aims to provide a gateway to high-quality, biomedical information on the Internet, MIDRIB (Medical Images: Digitised Reference Information Bank) can be found at:</td>
</tr>
<tr>
<td></td>
<td>General medical CAL packages on clinical decision making</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>School based availability</th>
<th><a href="http://www.bham.ac.uk/dentistry/hot">http://www.bham.ac.uk/dentistry/hot</a></th>
</tr>
</thead>
<tbody>
<tr>
<td><a href="http://www.bris.ac.uk/Depts/Dental">http://www.bris.ac.uk/Depts/Dental</a></td>
<td>School of Dentistry, The University of Birmingham Examples of CAL for downloading</td>
</tr>
<tr>
<td><a href="http://www.elec.gla.ac.uk/TILT/Dentistry.html">http://www.elec.gla.ac.uk/TILT/Dentistry.html</a></td>
<td>Bristol University Dental School Home Page:</td>
</tr>
<tr>
<td><a href="http://www.nmds.ac.uk/elsewhere/dental/denthome.html">http://www.nmds.ac.uk/elsewhere/dental/denthome.html</a></td>
<td>Glasgow University TILT Group in Dentistry:</td>
</tr>
<tr>
<td><a href="http://omni.ac.uk">http://omni.ac.uk</a></td>
<td>United Medical and Dental Schools Home Page:</td>
</tr>
<tr>
<td><a href="http://www.butterworth.heinemann.co.uk/ortho/ortho.html">http://www.butterworth.heinemann.co.uk/ortho/ortho.html</a></td>
<td>A sampler of CAL package in orthodontics, from Butterworth Heinemann OMNI (Organising Medical Network Information), based in Nottingham, aims to provide a gateway to high-quality, biomedical information on the Internet, MIDRIB (Medical Images: Digitised Reference Information Bank) can be found at:</td>
</tr>
<tr>
<td><a href="http://www.midrib.ac.uk">http://www.midrib.ac.uk</a></td>
<td>General medical CAL packages on clinical decision making</td>
</tr>
<tr>
<td><a href="http://www.ccc.nottingham.ac.uk/~mczwww/tltp.htm">http://www.ccc.nottingham.ac.uk/~mczwww/tltp.htm</a></td>
<td>General medical CAL packages on clinical decision making</td>
</tr>
</tbody>
</table>

An example of a CAL package using an authoring template is on the oral manifestations of HIV disease [34]. Again the template makes it much easier for subject specialists to be able to enter material into a CAL package quickly without having to spend a long time learning to become proficient in writing computer code [35].

8. How is CAL distributed?

In the early days of PC produced CAL, an application (such as a word processing package) would be able to fit completely onto one floppy disk, and still leave room for several document files to be stored. Nowadays, the increasing size of software (especially since the introduction of Windows 95), means that applications distributed on floppy disk tend to come on several floppy disks—despite the vastly increased storage size of modern day, high-density floppy disks. However, as entry level machines tend to come fully equipped with CD drives as standard, software is now frequently distributed (and often run from) CDs. These can hold nearly as much data as a hard drive—and certainly a great deal more than the days when a 20 Mb hard drive was considered ‘state-of-the-art’.

Another way to obtain CAL is over the Internet. Many organisations are now putting samplers of available software onto World Wide Web (WWW) sites, often as shareware (Table 2), that users can access and download to test. Sometimes this shareware will be in the form of a sampler of what is available from the distributor. On other occasions it may come with a time limit, after which time users will be expected to register and pay a fee in order to continue to use it. Occasionally users are able to test out the software, but not be able to save any work, until the full version was purchased. The advantage of shareware material is that users can try out the software before making a decision as to whether or not they want to buy it.

9. Remote accessing of CAL material

The Internet is a network of computers around the world that enables electronic information to be passed from one site to another [36]. The WWW was initially developed by scientists at CERN as a way to send images over the Internet, and has caught on in a big way with society. Images containing details relating to specific cases can now be sent by individual dental practitioners to specialist consultants for advice anywhere around the world and a reply received back as quickly as making a phone call. Both these can be employed to deliver computer-aided learning.

Since 1995 there has been an astonishing increase in the number of people linked to the Internet, together with an increase in the amount of information held electronically that is available via the Internet. According to Zimmerman [36], ‘The discovery of new tools adds to the human experience, but the ability to communicate and share that knowledge and wisdom results in a factorial increase in the collective wisdom of a global community.’ As well as giving access to individual CAL packages held at a variety of locations world wide, the Internet provides another area for using computers as a learning tool via access to facilities such as MEDLINE. A listing of useful Internet sites for CAL is shown in Table 2.

There are two ways in which computer-based teaching may be used ‘over the Web’. The first is on-line, using the computer as a terminal to access software running on a
machine many hundreds or thousands of miles away. Such an arrangement is expensive to the private user and is also very slow at the times of peak use of the Internet. There are preferable alternatives. The first is to ‘download’ whole packages from the Web at off peak times so that these can be used at leisure and over an extended period without further cost on the home machine. An alternative is to run a ‘closed net’ for a limited number of users who pay for the privilege. A different approach is to use high-data capacity telephone lines, which allow point-to-point communication between the two callers. ISDN (Integrated Signal Digital Networking) will allow a caller to access computer-based teaching material held at the local postgraduate medical centre. It is difficult to say at the present time which method of delivery will prove to be most attractive in the long-term. On the one hand, ISDN lines are relatively expensive to install but, on the other hand, delays in accessing material on the Internet are sometimes almost intolerable.

10. How is CAL organised: the UK model

The UK is unique as it established at an early time a structure for the production of CAL which effectively avoided duplication of effort. The Computers in Dentistry Co-ordinating Group was established under the auspices of the British Dental Association (BDA) in 1994. It arose out of a meeting held in June of that year entitled ‘computers in Dental Practice’ which set out to address the use of computers in education, audit, practice management and communication. By December of that year a formal structure had been set up with representatives of the BDA, Dental System Suppliers Association, Department of Health, Royal Colleges and University producers of CAL. The Computers in Dentistry Group acts as its name suggests in ensuring that the introduction of information technology in dentistry has proceeded smoothly and that material produced for teaching matches the platforms which are being used increasingly in practice management. The British Society for Computer Assisted Learning in Dentistry came into being a year later in September 1995 and the production of CAL has accelerated under its leadership.

Another organisation, the CTI Centre for Medicine, is also involved in the development of CAL in dentistry. The CTI Centre for Medicine is one of 23 specialist centres throughout the UK that have been set up to co-ordinate the development of computer technology for training purposes in specific subject areas. In this case, the centre offers advice, provides information, reviews, evaluations, support and encouragement to subject specialists interested in developing computer based teaching materials for medical education (including dental science). Funding for this centre comes annually from the English, Scottish and Welsh Higher Education Funding Councils and from the Department for Education Northern Ireland [37].

11. The future

It is a brave person who tries to predict what might be happening in even 6 months time in computing, let alone any longer. However, increasing computer power, more resources, growing interest from dental practitioners and greater awareness of what is available indicate that computing is here to stay and is going to have an enormous impact on all areas of dentistry, let alone on the way dentistry is taught. The introduction of the programming language JAVA will help to facilitate this move, by allowing cross-platform delivery of computer programs, so that users can access CAL packages on a variety of different computer bases—for example, when using a stand-alone IBM-PC compatible computer, an Apple Macintosh computer or a main frame computer.

Recent developments have promoted the belief that by the year 2005, students will be given lecture notes on floppy disks or CD-ROM, rather than on paper, gaining access to images and references via the Internet, with an emphasis on being able to acquire, analyse and use data becoming more important than the ability to ‘store and regurgitate data on demand’ [7]. As well as basic ‘drill and practice’ tutorials, virtual reality and case simulations will be more readily available, allowing students the opportunity to practice dealing with particular situations before encountering them for real [7, 38]. In addition, the Internet will have made life-long learning a realistic goal, with dental practitioners able to access the latest research and acquire further training over the ‘Net’ via such activities as video-conferencing. ISDN can offer further opportunities in this area [39]. Expert advice will be more readily available and accessible by the same means, with ‘expert systems’ able to offer advice on the latest recommended treatment plans or the need for referral 24 h a day.

12. Conclusions

The introduction of computers as an educational tool in dentistry and the provision of CAL will have an impact not only on how dentists are trained, but also on the skills they will need to acquire in the future to keep up with this new technology, a point echoed by Calman, when he noted that information technology would be of benefit to patients not only directly, but also indirectly ‘by giving clinicians rapid access to the up-to-date information which they need to inform and support their clinical decisions…’ [40].

However, it is the introduction of the Internet that will have the greatest effect on future provision of CAL internationally. As well as allowing dentists to communicate with other professionals outside their own working environment, the Internet will provide access to up-to-date training material for dentists no matter where they might be located [41]. As technology develops and improves, so the potential for continuing vocational training of dental practitioners...
will increase and information technology will play an even more important role in the future dental practice.

References

[40] Colman K. The role of informatics in the future NHS in Informatics in the Undergraduate Medical and Dental Curricula, Chapter 1. London: Royal Society of Medicine, 1996.