Techniques in medical education

Information technology in medical education: current and future applications

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Summary

Information technology has the potential to revolutionise the way medicine is learned by students and healthcare professionals. This potential was recognised by the General Medical Council in their 1993 report *Tomorrow's doctors* in which the need for future generations of doctors to be familiar with the application and scope of information technology is described. This paper focuses on the use of computers as aids to learning medicine and discusses two key applications of information technology to medical education: multimedia and the internet. The current use and potential for these areas of information technology are described and future developments discussed.

Keywords: information technology, education, internet, multimedia

IT awareness among Liverpool medical students, 1995*

- 92% use computers daily, most commonly word processors and video games
- 90% want to know more about computers
- 40% perceive a need for help using a computer
- 19% find computers difficult to use
- 47% thought they would be using a computer as a doctor
- 25% used computers at school

*n=116 (53% male, 47% female)

Box 1

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A rising tide of information technology (IT) is sweeping through medical education, providing learners with easier and more effective access to a wider variety and greater quantity of information. Following the trend of all new technologies, it is the younger generations who are more able to adapt and react to new technology. This was reflected in a 1995 IT awareness survey of 116 new medical undergraduate students in Liverpool, mostly aged 19 years. The survey was conducted using a questionnaire comprising 17 questions in the form of tick boxes and Likert scales. The results are summarised in box 1. These results show that a high percentage of the new students had used a computer before, mainly to word-process and play video games.

As IT plays an increasingly larger role in primary and secondary education we can expect that with each new intake of medical students, their knowledge and expectations of IT will grow. It is this increasing demand for IT in medical curricula that has the greatest potential to influence how medicine is taught and learned. This is reflected in developments in medical courses around Britain where medical schools are moving towards providing learning materials on computer.^{1,2} Over the last decade there have been two key developments in IT that provide new opportunities for medical education. These are multimedia and the internet. Breakthroughs in computer hardware (eg, Pentium™ processors) have made it possible to deliver the power of the older, bigger mainframe computer in affordable desktop and laptop computers. This, coupled with major developments in software, in window, mouse and pointer interfaces for computer operating systems, now makes it possible for the non-technical computer-user to carry out tasks that only programmers and technicians were previously capable of. For example, users can connect their computer to networks (eg, the internet) to send and receive information and they can use electronic mail to communicate with people around the world. Multimedia and the internet complement one another with the internet providing a means for instantly delivering multimedia information to an international audience. The following sections describe and discuss multimedia and the internet and illustrate how they are currently being used for medical education.

Multimedia

Multimedia computers can display information using a wide variety of formats such as sound, digital video, animation, pictures and text. Multimedia is not synonymous with CD-ROM. Although multimedia software is often stored on CD-ROM, because of the amount of storage space audio and digital video require, software is only multimedia if it uses multiple media to display information. For example, although the Oxford Textbook of Medicine is stored on CD-ROM, this program uses text alone to display information and is therefore not a multimedia program. However, Encarta™, a commercial encyclopaedia produced by Microsoft®, is a multimedia program because it uses digital video, audio, animation, graphics and text to present information.

A typical specification for a machine capable of running multimedia software is given in box 2. This specification gives a realistic bare minimum required to run multimedia programmes. The specifications in brackets show the industry standard for multimedia computers in July 1996. This specification will be out of date by the time this paper goes to press, giving an indication of how fast IT is evolving.

Multimedia in medicine is primarily used in computer-based learning (CBL) programmes primarily for undergraduate medical students. However, as CBL becomes an integral part of undergraduate medical curricula and further develops in terms of educational sophistication, materials for postgraduate and

Specification of a multimedia machine

- a fast 75 MHz processor chip (eg, Pentium™) (133 MHz)
- a 16-bit sound board (32-bit)
- a 1-MB video display board (4 MB)
- a Quad Speed CD-ROM drive (× 6 speed)
- 8 MB of Random Access Memory (RAM) (16 MB)

Box 2

Figure 1 A screen from Microsoft Bodyworks[©]

Categorisation of CBL programs

- information resources: reference/literature databases (eg, Medline)
- electronic textbooks: textbooks converted into electronic format (usually CD-ROM)
- tutorial: sequential lessons (usually multimedia) aimed at teaching specific subjects (eg, anatomy of the liver)
- mind tools: programs to help learners organise and plan learning (eg, personal information manager) and structure and record knowledge/information (eg, mindmap)
- study guides: programs designed to support an educational process (eg, problem-based or task-based learning)

Box 3

Figure 2 A screen from RALE™ heart auscultation program

professional learning should become available. There are many CBL programs for medicine that use multimedia to present and provide access to different types of information. For example, digital video clips of surgical procedures, animated anatomical structures and aural commentaries to accompany text. Figure 1 shows a screen from one such medical multimedia program that provides the user with both two- and three-dimensional images of the human skeleton. The 2D image can be used to identify structures and find out about their function. The 3D image lets the user rotate the skeleton around 360° to explore the relationships between the component parts.

There are different types of medical multimedia designed to address different learning needs. Box 3 shows the different categories of CBL programs in order of their educational sophistication. CBL programs classified as information resources are the most simple in terms of educational design and are primarily used as aids to finding information quickly. The 'mind tools' and 'study guides' program² offer the greatest potential for medical education for both undergraduates, postgraduates and healthcare professionals by encouraging an enquiry-driven approach to learning where the learner explores and investigates information to build links and relationships and form ideas and hypotheses. These activities are key to adult learning³ and will play a major part in new medical curricula, in particular problem-based courses.⁴ 'Mind tools' and 'study guides' are not only the most educationally sophisticated, they also require sophisticated computer programming techniques. Therefore, to develop these types of CBL program there needs to be a multidisciplinary approach that draws on medical education, computer science and medical content.⁵

Multimedia has the potential to provide learners with educational experiences that traditional text-based methods cannot (eg, interactive patient consultations). If, however, multimedia is used to demonstrate the technical capabilities of a computer and not set in an educational context, as is the case with many 'electronic' textbooks and 'tutorials', then the true value of multimedia is lost. An example of a heart auscultation CBL tutorial program which uses multimedia as an effective aid to learning is illustrated in figure 2.⁶ This program, RALE, uses animation combined with digital sound to illustrate the structure and function of the heart and the sounds associated with normal function and abnormal pathologies.

Multimedia programs are often described as 'interactive' and this is especially the case with educational programs. From an IT perspective 'interactive' is used to describe communication between a user and a computer. For many medical multimedia CBL programs this communication consists of 'button clicking' (eg, to show a picture or play a video clip) or 'electronic page turning' (eg, to go to another part of the program). This is the lowest level of interactivity where the computer is performing tasks (eg, showing a picture) requested by the user. This level of interactivity could be described as 'reactivity' and it is therefore somewhat misleading to describe CBL programs of this nature as 'interactive'. Truly interactive CBL programs aim to establish an educational 'conversation' between a user and a computer. This can be achieved using features such as feedback on strengths and weaknesses and progress charts linked to learning activities and self-assessment. It will take considerable computer power to develop a truly 'intelligent' program that can react to individual student's questions.

The internet (world wide web)

The internet is a global network of computers that allow information to be viewed or transferred from one computer to another. It offers facilities such as electronic mail, information transfer and the ability to search for information. The internet was until recently accessed using a 'command line interface' which required users to type in commands to perform tasks such as connecting to a computer, sending electronic mail or retrieving information and could only display text. The internet was therefore mainly used by computer programmers and technicians.

The world wide web (web) has changed the way the internet is used and who it can be used by. The web replaces the internet's 'command line interface' to provide a graphical user-interface which enables people with various technical abilities to use the internet. The web can display multimedia information and help users perform difficult tasks (eg, transferring information) with the click of a button. Figure 3 shows a typical screen from the internet and some web addresses of medical interest are given in box 4. For the purpose of this paper the terms 'internet' and 'web' will be used interchangeably.

A personal internet network account is required to access the web. Academic organisations, such as universities, usually provide an account free of charge for

Some medically oriented web pages

American Medical Association:
http://medweb/bham.ac.uk/

British Medical Journal:
http://www.bmj.com/bmj

Postgraduate Medical Journal:
http://www.postgradmedj.com

Virtual Hospital:
http://indy.radiology.uiowa.edu/

Visible Human Project:
http://www.nlm.nih.gov/

Yahoo search facility:
http://www.yahoo.com/

Box 4

Figure 3 A typical web screen viewed using Netscape™

their staff and students. Alternatively an internet account can be hired from a commercial supplier (eg, Compuserve, Daemon). A software program known as a 'web browser' is also required in order to view web pages. The browser converts web pages stored in 'hyper text markup language' format (HTML) into multimedia information. HTML was designed to enable the faster transfer of information across the internet. There are a variety of browsers available including Microsoft Internet Explorer™, NCSA Mosaic™ and Netscape Navigator™ of which the latest versions can be retrieved (downloaded) from the appropriate internet sites for free.

Web pages have an address, also known as a Universal Resource Locator (URL), which tells the computer in which country the internet page is located, what type of company/institution the page belongs to, the location of the page in the country (ie, City), and the name of the file to be accessed. To view a web page you therefore give the web browser the address of the page you wish to view (eg, the University of Liverpool's URL is <http://www.liv.ac.uk/index.html>). Every Web address starts with 'http://' which tells the 'browser' how to decode the information it receives from the Web.

The internet is primarily used in medical education to provide users with access to lecture notes, references, course materials and personal information. For example, a lecturer could make his/her lecture slides accessible on the internet. Tutorials addressing specific subject areas (eg, the treatment of breast cancer) may also be delivered on the internet and provide learners access to core texts and reference materials and self-assessment questions (usually multiple choice). Internet-based tutorials, lecture notes, etc, can be accessed from anywhere in the world connected to the internet (eg, a tutorial in Liverpool can be accessed by students in Harvard). This offers great potential for distance learning courses, both national and international. Because the course materials are stored in one place revisions can be made instantly available to all students. However, course materials produced using HTML, the standard mark-up language for the web, cannot be made intelligent or interactive because HTML is not a programming language (eg, it cannot manipulate information or make decisions).

The web is a continually evolving technology. Probably the most significant development at this time is release of the programming language Java™ (similar to the C programming language) developed by Sun Microcomputers. Programs written using Java™ are run over the internet via web pages. This means developers using Java™ will, by the time this paper goes to press, be able to produce intelligent and interactive web pages to provide the same functionality that some CD-ROM-based programs offer. To run Java™ programs, however, a Java™-compatible web browser is required (eg, Netscape Navigator™ version 2 or later).

The future

IT is advancing at such a pace that there is a continual flow of innovations offering new and exciting opportunities for medical education. We are currently at the dawn of virtual reality (VR) systems that enable users to explore and interact with real-time 3D worlds. Some VR programs already exist, although expensive powerful computer equipment is required to use them. There are already basic VR programs that will run on standard multimedia desktop computers and be accessed over the internet. These VR programs are based on the virtual reality modelling language (VRML) which enables 3D worlds to be built and made interactive. VRML (pronounced vermal) can transmit 3D worlds over the internet and standard web browsers now have plug-in programs that let users view and interact with these worlds. VRML has great potential for medical education, enabling learners to interact and manipulate structures. For example, a 3D anatomical representation of the heart could be modelled, using VRML, to beat (including sound) in real time. Learners could, in this case, explore the pumping mechanisms of the heart in three dimensions from inside or outside of the heart. An example of a VRML world is illustrated in figure 4 which shows a VR desktop for Liverpool's problem-based study-guides.² Desktop video conferencing is another development on the horizon which offers great potential for medical education and practice. Although video conferencing has been available for quite some time, it required expensive equipment and was costly to run because satellite time often needed to be bought. There are a range of desktop video conferencing packets that connect to standard multimedia computers and can use the conventional telephone networks or the internet. The equipment is relatively inexpensive and conventional telephone networks and the internet are relatively inexpensive compared to satellite time. Video conferencing has great potential for

Figure 4 Liverpool's virtual desktop for medical education

undergraduate, postgraduate and professional medical education in helping distance-based learners to communicate with their peers and tutors more effectively and more naturally.

Conclusions

Multimedia and the internet present great opportunities to support and enhance medical education. They provide learners with access to large quantities of information which can be searched and viewed in a variety of ways (eg, digital video, sound). The internet, in particular, can help learners from different countries to participate in, for example, tutorials and communicate with other learners and tutors. However, neither multimedia and the internet are currently being used to their full potential. The vast majority of CBL materials produced for medicine are in effect electronic textbooks which have very few educational benefits over paper-based texts. This may be the result of poor development approaches,⁷ where the emphasis is placed on technology as opposed to education. Producing educationally effective CBL materials requires a three-pronged approach encompassing computer science, medical education and medical content,⁸ with an emphasis on educational structure. Technology is in a position now to offer great potential for teaching and learning medicine. The challenge is to combine the expertise of technologists with the expertise of medical educators, clinicians and basic scientists in efforts to design and develop innovative approaches towards medical education that utilise IT to its full potential for maximum educational value.

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