Computer Applications in Medical Education and Training: A Brief Review

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Abstract

Computers have been used in medical education during the past three decades. It has however, gained wider applicability and acceptance during the past decade. Today, powerful microcomputers and user friendly computer software are increasingly being used in many areas of medical education such as simulations in basic sciences during undergraduate training, training simulations in surgical procedures during postgraduate education, medical curriculum development, evaluation procedures and in continuing medical education.

Computer assisted instruction (CAI) is increasingly taking on a new role as an alternative or an adjunctive medium of instruction at all levels of medical education. Because of the increasingly important role the information technology plays in different aspects of medical education, there is at present a growing need for the medical students to become computer literate early in their undergraduate careers. However, there are still many limitations of the use of CAI in medical education such as the initial cost of computers and software packages as well as the maintenance cost of this equipment, which is especially true for third world countries. The development of new low cost powerful microcomputers and global networks such as the Internet and the World Wide Web, Computer Technology is likely to be more widely applicable in several areas of medical education in the ensuing decade.

Introduction

Although the number of students entering the medical schools today with some computing experience is few, the academic staff of the faculties of medicine are increasingly becoming aware of the importance and the vital role played by computer software in. assisting their academic and research activities.

With rapid advances in medical education and the radical changes in the undergraduate medical curricula, it was found opportune to outline some important applications of computers in medical teaching and learning and its future prospects. The field is advancing so rapidly that no book can be up to date for long, and keeping abreast of the developments in computer applications in medicine is becoming increasingly difficult. It is evident that we are in a transitional phase in the application of computers in medical education. Except for the past decade, their use has been largely confined to specialised units manned by enthusiasts, who have advanced the application of computers in their own field of practice (Pradham & Dev; 1993). Now that the cost of powerful personal microcomputers has become affordable, it is becoming a common place utility.

The use of computers in medical education has been in evolutionary development since the early 1960s (Piemme; 1988). Its adoption however has been less widespread than was warranted. Computer Assisted Instruction (CAI) enhances learning, allowing the student the discretion of time, content, place and pace of instruction (Piemme; 1988). Information conveyed may be applicable to undergraduate, post graduate and continuing medical education (Pradham & Dev; 1993).

Background to Computer Education

The call for medical students to become literate in the use of information technology has been in existence for over a decade now (Koschmann; 1995). It was over 10 years ago that the Association of American Medical Colleges Report recommended that medical schools incorporate into their curricula, the use of computer technology for medical students to become computer literate (Koschmann; 1995). It will not only enable them to use information technology competently, but will assist in post-graduate and continuing medical education.

It was in the 1970s that computers were first made use of in teaching basic sciences using computer based programmes (Friedmann; 1995). These early results have been encouraging and it prompted the educationists to use CAI more widely in the following two decades. With the advent of low cost microcomputer technology, CAI has received wide spread applications such as clinical simulations (Chew and Smirniotopoulos; 1995).

Information technology has been introduced to medical students in several countries already. Most studies have found that men were more computer literate than women (Gouvela-Oliveira et al. 1994, Sancho et al. 1993, Kidd et al. 1993). However, without a gender bias, the majority identified CAI to be useful as a teaching medium to students and in future medical practice (Kidd et al. 1993). Therefore, the undergraduate curriculum should seek to promote a more self-educative approach, which was suggested by the General Medical Council in Britain in 1990 (Chessell; 1994;). One of the main proposals was the introduction of self-directed learning to reduce didactic teaching during the course, partially with the introduction of CAI (Chessell; 1994). A recent questionnaire based study, which was carried out in Portugal found that the medical students' attitudes towards CAI were favourable (Gouveia-Oliveira et al; 1994). The majority of students (with no significant gender difference) identified the need for the introduction of computer education in their undergraduate medical curriculum, even though only about half those questioned had any exposure to computers (Gouveia-Oliveira et al; 1994). However, the medical schools and teachers in them were late in adapting to the changing teaching techniques, which resulted in a delay in the use of CAI in teaching and training technology and were thus late in introducing computers as a day-to-day teaching aid (Chessel, 1994; Levy, 1989).

Early years of computers and teaching

Computers and the concept of Computer Assisted Instruction (CAI) were introduced into medical teaching almost three decades ago. Since then it has made great strides, particularly during the last decade (Piemme; 1988). Although, computer technology has progressed rapidly during the last decade, the use of CAI as an adjunct to traditional methods of medical education has made limited progress globally (Levy; 1989). However, the advent of cheap and powerful microcomputers has opened the possibility of CAI in medical education to be more widespread by the beginning of the 21st century (Clayden and Wilson; 1988). It has been found that CAI in medical education can be of help to liberate students from the burden of learning of facts and enhance the role of reason and imagination in the learning process.

One important aspect of computer applications in teaching and training at both undergraduate and postgraduate education has been the development of computer models and simulations (Stocking and Mo; 1995; Ostrow et al. 1975; Prentic and Kenny, 1986; Fingert and Schneider 1994). Simulations as an instructional technique are being utilized for the learning of clinical skills in the training of medical students and doctors. It was as far back as 1975 that simulations on pulmonary function tests were introduced in USA (Ostrow et al., 1975). Significantly, CAI in clinical teaching and diagnosis was found to be more acceptable and favoured compared to other teaching methods in surveys

conducted more than 10 years ago (Prentic and Kenny; 1986; Fingert and Schneider; 1994).

The Internet World Wide Web and Interactive Multimedia in Medical Education

Technology is revolutionizing education today. Global networks, powerful personal computers and user friendly graphically oriented software are creating an environment, which gives rapid access to information (McEnery; 1995). The Internet, World Wide Web (WWW) and Mosaic are such networks, which have made a significant impact on CAI.

There are now several interactive multimedia software available for medical education. Such packages are distributed over compact disk-read only memory (CD-ROM), floppy disks and laser video disks (Quinn et al., 1984). The target audiences are usually medical students, doctors, health administrators as well as patients. Recent research has found that such multimedia textbooks, when compared to printed textbooks and standard lectures, prove to be an educationally sound alternative instructional method with a promising future in undergraduate medical education (Poses et al; 1992). A major limitation of the use and popularity of their use has been the high cost and relative non-availability of these software in most countries outside the developed world (Clayden and Wilson; 1988), and the inexperience of the teaching profession to use them (Piemme; 1988). The multimedia textbook was found to be more effective than the standard lecture and as effective as the printed textbook (Santer et al., 1995). However, much needs to be done to improve the reliability and dependability of the contents of information presented in the new multimedia systems (McEnery et al; 1995). Methods have also been devised to utilize the WWW for interactive teaching in some disciplines such as Radiology in USA (McEnery; 1995).

The practicing clinicians in hospitals do not have the same computer based facilities for CAI as those based in the universities. The Internet, which contains a vast amount of medically relevant information, has been employed to link universities with such off campus sites in USA and in future proves to be a useful link between the university hospitals and clinicians (Constantinou et al.,1995). However, even in the developed countries such as USA, where CAI was introduced nearly three decades ago, its use is still limited due to the fewer WWW site available for users in medical education (Constantinou, et al, 1995), and also due to insufficient incorporation of reliable information on topics of medical relevance (Stocking and Mo; 1995).

CD ROM and MEDLINE in Medical Education

Computerized literature searching system was introduced to the medical profession in the 1980s (Markert et al., 1989). Since then it has seen a very rapid development with the culmination of the compact disc-read only memory (CD-ROM), which has been used to store medical literature (MEDLINE). The CD-ROM is a striking new development. These disks have the capacity to hold up to 550 megabytes of digitally stored information. That amount of storage is roughly equivalent to six complete sets of Encyclopedia Britanica (Piemme; 1988). Medically relevant information is now commercially available on National Library of Medicine's MEDLINE on CD-ROM disks.

Several studies have been conducted to assess the usefulness of MEDLINE and CD-ROM in assisting medical students education (Schwartz et al; 1995, Pao et al 1993, Haynes et al., 1993). These studies have consistently found that once the students are exposed to the MEDLINE search, the frequency of use by the students increases significantly. However, these studies have all been carried out in countries where multimedia facilities have been available for sometime. It will be very difficult for such a study to be carried out in a developing country due to the lack of exposure to such information technology (Piemme; 1988, Levy; 1989). Therefore, more exposure to

MEDLINE during medical school could play an important role in developing effective literature searching skills for not only in undergraduate medical education, but also in post graduate and continuing medical education, the last being essential for today's health professionals (Pao et al., 1993). However, the cost of such software would still be a major limiting factor in the world wide use of this information technology (Levy; 1989, Clayden, and Wilson; 1988).

Computer Assisted Instruction (CAI) and Simulations in Medical Education

Computer based clinical simulations have been used in medical education during the past 25 years. During this period, the technology has evolved from mainframe computers to microcomputers to multimedia. The CAI fulfills an important need for pictorial representation of the functions of organs and systems. Various computer techniques of animation (simulation) are now available in medical educational technology (Habbal and Harris; 1995). Basic science subjects such as Anatomy, Physiology and Biophysics are increasingly being taught using computer simulations (Schubert et al.,1994; Lilienfield et al.,1994; Samsel et al., 1994).

In anatomy, computer models have been designed for situations such as teaching of cardiac anatomy and thoracotomy (Champman et al., 1994; Stanford et al., 1994). However, it was found that CAI should not replace dissection in teaching anatomy, but should be used as an adjunct to it, because computer instruction after dissections was found to dramatically improve the testing performance of students (Stanford et al., 1994).

Physiology is increasingly being taught using CAI (Lilienfield and Broering,1994; Samsel et al., 1994; Mangione et al., 1991; Boyle et al., 1991). Multimedia presentation of lung sounds in undergraduate teaching has been found to be useful for learning and understanding of lung sounds in a study in Chicago, USA (Samsel et al., 1994). The digitalised lung sounds were played and the corresponding waveforms were commented on and displayed on a computer. The great majority of students found the association of the acoustic signals with their visual image more useful than the physical examination of the chest only (Samsel et al., 1994). Comparisons of computer simulations versus animal demonstrations in Cardiovascular Physiology teaching were found to be highly rated by students at the University of Chicago medical school (Samsel et al., 1994). However, CAI received a higher rating. It is likely that CAI facilitates learning in many situations or as equally effective to traditional teaching methods given sufficient exposure (Lilienfield and Broering: 1994), which however is lacking in most parts of the world (Piemme; 1988, Levy; 1989, Clayden and Wilson; 1988). A comparison of CAI and small group teaching of cardiac auscultation to medical students found that CAI is at least as effective as small group teaching of cardiac auscultation to third year medical students in USA (Mangione et al.,1991). Similar results were obtained when ventilator control simulation was introduced to second year medical students (Boyle et al.; 1991). It is quite possible that this approach using computer simulations provides a number of additional benefits that are normally lacking in a lecture based practical session.

Although the use of CAI in the medical undergraduate curriculum is increasing, little was known regarding the acceptability of CAI among medical students. A study carried out at the University of Sydney, Australia has found that computer anxiety among medical students was negligible when using CAI and, that there was a high level of acceptance of this type of instruction (Khadra et al., 1995). This is encouraging for medical educators involved in producing multi-media packages for teaching medicine and surgery. Even among intern doctors, it was found that following exposure to CAI on clinical information system use, the computer anxiety was significantly reduced (Brow et al., 1994). However, most medical educators, who are involved in the development of such software packages have not yet integrated themselves into a team, which has inputs from different segments

of the medical education and informatics sectors to develop user friendly reliable software packages (Levy; 1989, Brow et al., 1994, Ota et al.,1995, Goonewardena; 1997).

Virtual reality (VR) is an emerging technology that can teach surgeons new procedures and can determine their level of competence before they operate on patients (Ota et al.; 1995). Medical applications of VR are just beginning to emerge. These include surgical simulators, beginning telepresence surgery etc (Ota et al.; 1995). Such simulators are being used to train doctors in various surgical techniques such as arthoscopy (Dumay and Jense 1995), endoscopic surgery (Scott-Conner et al., 1994) and laparoscopic surgery (Dubois et al.; 1995) and in training in eye surgery (Sinclair et al., 1995). VR also allows the trainee to return to the same procedure or task several times later as a refresher course. Laparoscopic surgery is one of those skills for which VR is used. The major teaching/ training limitations identified with such techniques at present are the high cost of software, lack of experienced training staff and the initial acceptability by trainees (Goonewardena; 1997, Curry et al., 1984). These techniques will have limited use, especially in developing countries and the third world (Levy: 1989, Clayden et al., 1988, Curry et al., 1984).

Medical Curriculum Development

Another application of computer software is in the development of undergraduate medical curriculum content and in the development of integrated curricula (Burrows et al., 1989). This allows for quick and multiple access to the information and allows each department or teaching block to review the complete curriculum quickly, identify redundancies and more fully integrate new or existing material. The curriculum integration is gaining acceptance as an effective approach to teaching information skills and computerized bibliographic databases can be made use of for development of such an integrated approach (Young; 1995). However, most medical schools still have departmental barriers, and are resistant to change, which has resulted in slow progress of the process, despite the knowledge that blurring of boundaries between disciplines continue to occur (Koschmann, 1995, Chessell; 1994).

Continuing Medical Education

Continuing Medical Education (CME) is a key feature of ensuring quality delivery of health care by doctors. In a rapidly changing technological environment, it is important that medical education is undertaken in an effective and efficient manner. Physicians can use personal microcomputers for CME. Advantages of computerized CME include local control over the topic, time, place and pace of instruction (Goonewardena: 1997). Computers can be interactive, providing selected information that depends on the desires and needs of the physician. Learners have different preferred styles of receiving information and computer programmes can be written to appeal to a particular style of learning which will result in the development of programmes and packages much more dependable and attractive to the inexperienced in multimedia use (Goonewardena; 1997,Burrows et al., 1989).

Computers in Evaluation

The computer's role in evaluation is equally significant (Worthley; 1985). Computer programmes have been used to develop files of multiple choice questions (MCQ) and in the correction of MCQs. It allows an examiner to review the student's answers individually or collectively, updating the item discrimination or difficulty indicating each time a student performs the test. It also provides the option of answering the question with or without review of the correct answer and reference (Worthley; 1985).

Conclusions

Already computer technology has found numerous applications in the field of medical education. The past decade has witnessed most of these prolific developments. With the increasingly important role computers play in different aspects of medical teaching, the need for medical students to become computer literate is becoming a growing need as we prepare to enter the 21st century. Today, CAI is assisting in training at undergraduate, postgraduate and continuing medical education levels, and is likely to contribute significantly to the production of tomorrow's doctors globally.

However, there are still significant limitations in the use of computer information technology. They are the initial cost of computers and computer software packages, the maintenance cost of the equipment, training of staff to man such units, the lack of experience of medical educators with the new technologies associated with Informatics and the initial reluctance of the users. All of these have significantly hampered the growth of this new medium of instruction in the developing or the third world.

With the advent of global communication networks such as the Internet and the World Wide Web and low cost powerful microcomputer technology, it is likely to provide a much wider exposure, usage and applicability, resulting in a significant impact in the field of medical education in the coming decade.

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