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THE TEACHING OF MEDICAL INFORMATICS TO MEDICAL STUDENTS INCLUDING A RETROSPECTIVE EVALUATION

It is commonly suggested that (i) Information and Communication Technology (ICT) is essential for the delivery of quality healthcare [17], and (ii) the role of doctors is crucial in the implementation of ICT-based systems in hospitals and in general practice. Based on these two premises, this paper argues for a medical informatics course for medical students.

The paper outlines the content of a one-semester elective in medical informatics that was presented over eight academic years. The course pre-dates the recommendations of the International Medical Informatics Association, IMIA [7]. Nevertheless, it is compatible with the recommendations of IMIA and also with the earlier findings of the EDUCTRA study [5]. The principles formulated in this paper are presented in order to help other educationalists (i) to obtain insights and (ii) thence to assist them to engineer medical informatics changes into their medical school environments.

Each time that the course was presented, participants were asked for their evaluation of the course [9]. These views were favourable. It was thought that a follow-up survey of these same respondents - now practising doctors, some of whom took the course 10 years ago - might give further insights into the relevance and value of this course. The views of these practising doctors are presented within the paper.

1. INTRODUCTION

Starting from the propositions that (i) the discipline of informatics is important for the delivery of healthcare and (ii) the role of medically qualified staff is critical in decision-making in hospitals and in general practice related to the implementation of computer-based systems, this paper argues the need for a medical informatics course for medical students within their medical education. The main features of this course for medical students are outlined [14], and then the results from a survey of practising doctors, who undertook this medical informatics course when they were medical students, are presented.

It has been asserted that there is significant economic relevance of Information and Communication Technology (ICT) for (a) medicine and (b) the effectiveness and quality of healthcare; and that ICT offers enormous potential for the delivery of healthcare [6, 11, 16]. Although some have questioned this claim - e.g. Kun [8] asks for studies to be undertaken to prove the medical effectiveness of these technologies - it is generally thought that ICT brings benefits to healthcare [3, 16]. This is consistent with the British Government's decision in 2002 to increase ICT expenditure in the NHS from its current £1.1bn to £2.2bn in 2003/2004 [15, 17]. Therefore it

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can be argued that all healthcare professionals should learn and gain knowledge of health informatics. This, in turn, should lead to improved efficiency and quality of healthcare. In addition, if one also accepts that the role of medically qualified staff is critical in decision-making in hospitals related to the implementation of ICT-based systems [9, 18], then there would appear to be a strong case for a medical informatics course for medical students. These views are consistent with the directives of the American Association of Medical Colleges [1, 2]. The AAMC says:

"Physicians will have to possess the knowledge, skills, and attitudes required to be competent in medical informatics if they wish to incorporate into practice systematic approaches for promoting and maintaining the health of defined populations" [1]

This paper outlines the content of an elective in medical informatics. Although the course was designed before the recommendations of the International Medical Informatics Association (IMIA) were formulated and also before the AAMC proposals, the course is compatible with both IMIA and AAMC recommendations [1, 2, 7]. At the time when the course was presented, all participants were asked for their evaluation of the course [14] and the feedback was favourable. At a later date, it was thought that a follow-up survey of these same respondents - now practising doctors, some of whom took the course some 10 years ago - might give further insights into the relevance and value of this course. These views are presented in the paper. In summary, this paper outlines (i) the content of a course that has been implemented successfully and (ii) the opinions of doctors who studied on this course.

2. DO MEDICAL STUDENTS NEED MEDICAL INFORMATICS EDUCATION?

There is no longer any real debate concerning the significant positive contribution that ICT can make to healthcare [1, 17]. If this evidence is combined with the fact that many authorities - such as the Association of American Medical Colleges [1, 2] – have stressed the importance of medical informatics within the medical school's basic curriculum, one might have expected significant changes to the teaching of medical informatics over the past 15 to 20 years related to the teaching of medical informatics to medical students. This is not the case. Medical informatics is still not commonly taught within medical schools, causing Bailey-Geraghty recently to write "little or nothing has changed since the AAMC's 1984 recommendations" [3].

There are many reasons for the delay in the introduction of the academic subject medical informatics within the medical school curriculum. One is the conflicting calls on teaching time within medical schools. This makes it extremely difficult to accommodate a new academic subject, such as medical computing. These difficulties were recognised, and consequently in 1987, as an experiment, an elective course unit was introduced within the Intercalated BSc. at St. George's Hospital Medical School.

This paper outlines this course, which focuses on computing related to clinical and hospital activities. These computing applications are both meaningful and motivating. Whilst the medical informatics course includes computing techniques for improving study skills, these are not central to the course objectives. Indeed, the core objectives are based upon much broader principles that will be of long-term benefit to the participants in their practice of medicine. These relate to:

(1) the role of ICT in the delivery of health services
(2) an appreciation of the technical complexities, the difficulties inherent in the management of change, and costs related to computing and software development, and
(3) the use of computing as an aid to problem solving in healthcare and in medicine.

3. AIMS OF THE COURSE

There are many approaches for the teaching of computing. At the lowest level, a course can concentrate on keyboard skills such as those required for word-processing, spreadsheets and databases or to improve study skills. Another approach is to hope that computing education will be achieved as a by-product of teaching another undergraduate academic subject that uses computers. In this situation, a course may claim to be a computer course when, for example, it is more accurately described as a statistics course or an information retrieval course. This can be to the disadvantage of both the computing and the other academic subject. Another approach is to present an undiluted computer science course related to computer hardware and software. All these approaches were rejected.

In this case, it was decided from the outset that a computing course related to clinical and hospital activities would be most meaningful and motivating for medical students. The St. George's medical informatics course, entitled "Computing and Information in Healthcare", started from the assumption that computing is a fascinating academic discipline that medical students will enjoy. Like university students from other professions, medical students will not be motivated by computing linked to a non-major academic subject, but as a result of the computing being related to their clinical and hospital activities. Therefore, the "Computing and Information" course module has (i) a major educational aim and (ii) a minor study skills aim. The main aim of the course is to give students an understanding of the contribution computing has made and will make to better healthcare through:

(1) organisations using ICT, i.e. use in hospitals and general practices, and
(2) personal use by students in their future medical careers.

The minor aim of the course is to give students skills and confidence to exploit software packages to improve the effectiveness of their studies i.e. computer literacy.

4. THE COURSE – ITS CONTENT

There are many structures that a medical informatics course can adopt. A course can have horizontal integration or vertical integration. In the case of horizontal integration the computing is integrated with the academic subjects which are taught alongside the computing; and with vertical integration the computing is integrated with the clinical future of the students. Vertical integration was selected for this course. Within this framework, computer applications were selected to demonstrate the importance of ICT in healthcare at a level appropriate to the students' knowledge and experience i.e. for students who had completed their first two years of medical training. These applications were systematically sequenced within a problem based learning environment. The three core areas of the course were:-

(1) the role of ICT in the delivery of healthcare - this included both successes and failures so that students appreciate both the opportunities and the organisational issues related to large and small information systems and how computing often brings change and consequently problems [10]
(2) an appreciation of computing through program design and coding - this provided insights into the technical complexities of computing software, and
(3) the use of modelling and simulation techniques for problem solving demonstrated through modelling (i) an accidents and emergency (A&E) clinic and (ii) the management of an influenza epidemic.

The learning strategy presented all these various topics as an integrated whole through a series of seminars, tutorials, and case-based assignments that addressed the main areas of the syllabus. The laboratory work and the course project used problem-based self-directed learning, which is ideal for well-motivated students. Tutors provided continual opportunity for assistance, because the majority of students had little previous computing experience. The supervision, however, needed to be attentive, without being obtrusive. The topics covered in small group seminars are shown in Table 1.

1. Clinical decision support systems; expert systems or intelligent knowledge based systems in oncology and cardiology e.g. pacemaker selection; and neural networks related to asthma. [13]
2. Hospital information systems and patient bed-side monitoring systems. Safety critical systems.
3. Human computer interface. Computer security, privacy and confidentiality. The vulnerabilities of statistical databases. The special requirements of medicine.
4. Medical decision making and probabilistic medical reasoning.
5. Case studies - El Camino Hospital clinical information system; Wessex Regional Health Authority information system; London Ambulance system. ICT costs and the impact of change. [11, 12]
6. Computer programming. Mathematical modelling and simulation; and the application to management of an influenza epidemic and to an accident and emergency clinic.
7. Information systems design and evaluation. Control systems in nuclear plant. Quality assurance and the difficulty of proving system correctness.
8. The use of ICT in general practice
9. Computers in medical audit.

Tab.1. Topics covered in small group seminars

5. EXPERIENCE OF OPERATING THE COURSE

The first course was presented in 1987. Over the following years, the course remained essentially the same, but each year there were minor improvements. These modifications were made in response to student or tutor suggestions [14]. For example, in the mid 1990s neural networks were introduced to complement expert systems that had been taught from the initial implementation of the course [13].

The type of students that undertook the course each year were remarkably similar i.e., some 20% to 30% could be described as computer enthusiasts; and 70% to 80% were relative beginners. However, no students had any previous experience or knowledge of the role of ICT in healthcare [16] which was the main material presented in the course. The written examination was based on material from the lectures, seminars, private study and coursework assignments and consequently, all students had equal opportunity to do well, without undue influence from previous experience.

6. EVALUATION

All students completed two questionnaires, within the course time span. The first, at the start of the course, provided information about each student's previous experience of computing. It identified any student who might have some special degree of difficulty and consequently experience initial problems with the course. The second questionnaire was completed at the end of the course after all assessments had been completed. This allowed students to feel completely free to express opinions without fear that their opinions might affect their grades. This second questionnaire was an essential part of the formal evaluation. It provided qualitative data from students with respect to the strengths and weaknesses of the course in terms of (1) the course themes and (2) the teaching methods used to present these themes. Questionnaires together with the formal in-course student coursework assessments provided (a) the basis for recognising if the competencies achieved matched the course objectives and (b) as the basis for making amendments to the course unit.

The success of the course "Computing and Information" can be measured in terms of (i) number of students that selected the elective (ii) satisfaction of the students who completed the course, as expressed (a) in the end-of-course questionnaire and (b) through an independent student report [14], and (iii) academic achievement in the course assessments. In terms of all these criteria, "Computing and Information" was successful. The unit competed for students alongside special course units in biochemistry, immunology, physiology, anatomy and pharmacology. It was successful in attracting students in similar numbers to the most popular and traditional options. In the initial years of operation the number of students choosing medical informatics was small. This was expected because both the academic subject - medical informatics - and the tutors were unknown to students. However, in subsequent years, because of student recommendations, numbers trebled each year until quickly the course had its full complement. The questionnaires indicated that the medical informatics course achieved its aims and objectives, and similarly the coursework assessments and examination results were excellent.

The successful implementation of the course was due, in part, to the enthusiasm of the tutors. The tutors wanted this initiative to work successfully. However, probably the most important factor relating to its success is the subject matter of medical informatics. It is exciting and multi-dimensional (i.e. it includes technical, organisational, economic and medical issues) and consequently, medical informatics, by its very nature, appeals to students.

7. A RETROSPECTIVE EVALUATION BY DOCTORS

All the medical students that undertook the medical informatics course are now practising doctors. Some left the medical school in 1994 and others more recently in 1997. During this period, there were 42 students that undertook the medical informatics course. A student completing medical training in 1994 studied the medical informatics course in 1991. It was thought that their retrospective views concerning the course would be valuable. Unfortunately, as doctors in their early careers are changing employment every six months, they are extremely difficult to locate. Therefore, it was not possible to make contact with all the ex-students. Despite these problems, the addresses of 25 of the 42 doctors were located and questionnaires were sent to these 25 doctors. This represents 60% of the students that undertook the computing course; and fortunately the response rate from the 25 doctors was 100%. The sample was formed of 36% females and 64% males.

7.1. THE QUESTIONNAIRE – ITS PURPOSE AND DESIGN

A two-page A4 questionnaire was prepared. Respondents were asked for their views to a number of statements. A response was selected from four responses, i.e. “Strongly agree”, “Agree”, “Disagree” and “Strongly Disagree”. As a neutral answer was not possible, this ensured that respondents ‘took a stance’. The aim of the questionnaire was to ascertain the views of ex-students regarding (1) the general impression that the course had left with the students after 4 years or more of medical practice, (2) the usefulness of the course material in terms of their careers to-date, and (3) the relevance of a medical informatics course within a medical school. The questionnaire included other questions such as what computing courses they had attended since leaving medical school, and suggestions for material that might be added to the course, based on their medical experience. It cannot be claimed that the sample is perfect in any general scientific sense. Nevertheless, the survey does allow some general conclusions to be drawn, as shown below in Section 6.2.

Question to Doctors	SA	A	D	SDA
The MI course was helpful to me as a student	48%	52%	0%	0%
I would encourage other medical students to undertake a similar course (with appropriate updating)	44%	56%	0%	0%
The course was a stimulus for a continuing and further interest in computing	24%	56%	20%	0%
SA= Strongly Agree A= Agree DA= Disagree SDA=Strongly Disagree				

Tab.2. General value of the Medical Informatics course

7.2. ANALYSIS OF THE RESPONSES

7.2.1. GENERAL VIEWS CONCERNING THE COURSE

It is between five and eight years since the doctors whose opinions are shown in Table 2 undertook the informatics course at St George's. The views of the doctors will be influenced by their real-world experience. The data presented in Table 2 indicates strong approval for the medical informatics course described in this paper. There is unanimous support of the views that (i) the course was useful to the respondents when they were students and (ii) they would recommend medical students to undertake a similar course.

The knowledge/skills have proved useful in:-	SA	A	D	SDA
A clinical setting	12%	60%	24%	4%
A research setting	16%	68%	12%	4%
My professional development	32%	64%	4%	0%
SA= Strongly Agree A= Agree DA= Disagree SDA=Strongly Disagree				

Tab.3. The value of the skills and knowledge acquired

7.2.2. ITS USEFULNESS IN THEIR PROFESSIONAL CAREERS

Table 3 relates to the usefulness of the knowledge and skills that the doctors acquired from the medical informatics course for their subsequent work in clinical settings, in research and for their professional development. The data clearly demonstrates the positive value of the course, but the fact that 96% of the respondents considered the knowledge and skills acquired from the course to be helpful in their personal professional development is an extremely high commendation.

7.2.3. SHOULD MEDICAL INFORMATICS BE TAUGHT IN MEDICAL SCHOOLS?

The last table, Table 4, shows the respondents' opinions concerning whether or not medical informatics should be taught in medical schools. The replies were 100% in support of an elective in medical informatics outside of the main medical course, i.e. a course located in a similar place in the curriculum to that which they received. When asked about an informatics course placed within the core medical education in medical schools, 80% replied in the affirmative. These replies are of course in line with the recommendations of IMIA and AAMC [1, 2, 7].

The place for a medical informatics course	SA	A	D	SDA
An option outside of medical education as it is now	64%	36%	0%	0%
An option in main medical school curriculum	36%	44%	16%	4%
A core subject within the main medical school curriculum	24%	56%	20%	0%
Medical informatics should not be offered in the school	0%	4%	24%	72%
SA= Strongly Agree A= Agree DA= Disagree SDA=Strongly Disagree				

Tab.4. The need for a Medical Informatics course in a medical school

7.2.4. OTHER COMMENTS

With respect to suggestions for additions to the course, these included the paperless hospital, web based programming, and more material on GP systems and security.

8. CONCLUSIONS

The survey outlined in Section 6 provides (1) strong support for the course that the respondents undertook as medical students and that has been described in this paper, (2) evidence that the material within the course has been useful in the personal professional development of the respondents, and (3) support for the case for medical informatics being taught in medical schools. This view is consistent with the recommendations of AAMC [1, 2].

However, the fundamental issue that underlies the results reported in this paper concerns approaches to the teaching of computing to medical students. At issue is whether computing should be introduced into the curriculum through (1) forming the practical element of another subject (e.g. statistics or information retrieval), (2) training that improves study skills (such as skills in word-processing and use of databases), or (3) focusing on the role of ICT within healthcare provision. Other authors have reported negative results with the first of the approaches outlined above [9]. Certainly the second option is a necessary but not, we feel, sufficient condition for an approach to computing education that will meet the aims already described. In this paper we report positive results from experience with a course that follows the third approach - namely, teaching computing by focusing on the role of ICT within health care and medicine, i.e. the teaching of medical informatics. The approach advocated here, and by other authors, has been shown to achieve the educational goals required while appealing to medical students. The underlying principles of this approach are to give an appreciation of (1) the role of ICT in the delivery of health services (2) the technical complexities and costs of computing software and (3) the use of computing as an aid to problem solving in healthcare and medicine. Knowledge of these principles is gained by the students through the study of well understood clinical and hospital activities, subjects which appeal to medical students. Hence the computing is set in a relevant clinical framework within which the important ICT issues may be explored directly. It is the only approach that will prepare students for participation in the complex ICT issues with which they will be confronted during their professional careers [1, 2, 17].

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