Information and Communication Technologies in Medical Undergraduate Education

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Abstract

There is currently an international trend to involve information and communication technologies to support medical curricula and continuing medical education. In 2003, the School of Medicine, Democritus University of Thrace, Greece, was granted a 2-year fund to reform its undergraduate curriculum by introducing new technologies (under the Operational Programme for Education and Initial Vocational Training, financed by the Greek Ministry of National Education and Religious Affairs and the European Community). This paper reports on the technical and methodological approach adopted for developing an integrated e-learning environment, as well as on research efforts to address integration issues with the healthcare environment where a considerable amount of medical information is generated.

Key Words: educational technology, world wide web, web services, medical informatics

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Introduction

In recent years, advances in information and communication technology (what is often collectively referred to as "new technologies") have acted as catalysts for significant developments in the sector of health care, having a strong impact in supporting medical diagnosis, enabling efficient and effective patient and healthcare management and reforming medical education. There is currently an international trend to involve computers and the Internet in medical curricula as well in continuing life-long medical learning. This practice is reinforced by active support and funding from bodies such as the European Union and local governments. Specifically, the European Council in its Lisbon meeting in March 2000 set forth the European policy for an information and knowledge-based society, stressing the need to encompass the emerging technological revolution and change in the exchange of knowledge affecting all institutions and various aspects of the society (European Council, 2000).

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Communication and Information Technologies in Medical Education

The increasing employment of new technologies in higher education is also strongly related to an emerging trend in education that shifts attention from *teaching* to *learning* (Lin & Hsieh, 2001). In addition to these overall tendencies,

when medical education is considered new technologies are often employed to address current challenges and facts in medical education that include the following:

- raw clinical data and medical knowledge are increasingly produced, stored, and distributed in digital formats via networks (private and/or public),
- shortage in medical personnel and increase in clinical workload often put teaching second to clinical work,
- the academic as well as the closely associated healthcare system often encourage more profitable activities, e.g. clinical work or research, rather than teaching,
- enhanced awareness about the patient's overall well being may discourage direct clinical practicing and teaching in the clinical ward in several situations.

When new technologies where first introduced in education about two decades ago (although experimental attempts date back to 1970s), there was a considerable hype about the emerging electronic teacher, which fortunately soon enough subsided to reveal serious limitations of the computer-to-student education model (Dertouzos 1997). The traditional two-fold model of medical education, theoretical instruction based on textbooks and clinical practice with one-to-one interaction, need not be reformed (Gunderman *et al,* 2004). Employing new technologies should just aim to support and enhance (not replace) already proven educational techniques and processes, mainly by extending the amount and availability of knowledge and instruction as well as the place and duration of the educational process.

Like many other cognitive domains, medical education can be considered in terms of three levels of increasing complexity and importance (Davenport & Prusak 2000): information (i.e. simple facts), knowledge (i.e. information with a purpose), and understanding (i.e. conscious knowledge, achievement of explanation and grasp of reasonableness). Technology can be employed in diverse ways to support different levels of the educational process.

Supporting the dissemination of information is the easiest and most straightforward achievement of information and communication technologies. They have extensively and successfully been used to give quick, easy and cheap access to information sources, such as books, textbooks, atlases, medical and biological databases, research journals etc. What lies ahead is developing information processing and management tools that will help the reader and instructor with the overwhelming amount of information digitally available for network distribution. However, there is another aspect of information when medical education is considered: data that arises from the clinical practice and routine medical procedures. This major pool of medical information suitably enough nowadays is generated increasingly in digital format and is managed and distributed with information systems and over computer networks (e.g. digital output of various diagnostic and interventional devices, the various components of the electronic healthcare record, clinical workflows, etc.). We strongly believe that new technologies can mostly help dissemination of information in medical education by providing tools and middleware solutions to bridge the networked healthcare domain with the classroom, i.e. to seamlessly integrate healthcare information systems with academic tools and processes, either computer-based (e.g. e-learning environments) or even traditional (e.g. the classroom or the patient's bed in a University Hospital).

Structuring and organizing information with a particular educational purpose refers to knowledge. On the other hand, understanding implies experience as well as inquiring (Williamson *et al.,* 2002). Managing and supporting these levels of the educational process is a rather complex issue. Technology can certainly help by providing digital teaching files for the student to practice, together with tools that support continuous self-evaluation and mediate teacher-learner exchange. Of major importance is the potential of hypertext technology to provide interconnected pieces information, and link questions with explanations within the wider scope of a particular medical task.

The following paragraphs report on our efforts to employ new technologies to support medical education at various levels, ensuring educational module consistency and reusability. Current research work focuses on the problem of enhancing the synergy between healthcare enterprise and the academic world.

Introducing New Technologies in Medical Education at DUTH

In 2003, the School of Medicine, Democritus University of Thrace (DUTH), Greece, was granted a 2-year fund to reform its undergraduate curriculum by introducing new technologies, under the Operational Programme for Education and Initial Vocational Training, financed by the Greek Ministry of National Education and Religious Affairs and the European Community. Fully recognizing the fact that technological achievements cannot replace the teacher, the aim of this project is to exploit technology to support medical educators and students where and when this is needed. In specific, main targets of the project include the following:

- provide the means so that the educator can easily combine and point to various sources of information (instead

of the single textbook and the limited resources of the occasional library of a regional university), and guide the student to discover and explore further educational resources using the Web as well as specific medical data bases,

- exploit to the full the structure and functionality of hyperdocuments to help students create their own path in navigating through information, thus supporting self-guided knowledge extraction,
- create a framework for virtual collaboration of students and teachers, which among else addresses the problem of the often unreachable medical educators due to clinical commitment,
- promote rich self-evaluation mechanisms with appropriate links to explanations and further knowledge, and thus support understanding through continuous questioning and problem solving,
- bring real clinical practice into the lecturing theatre through video and audio trasmissions, to enhance quality of patient care, help educators to better manage time schedule, and provide the students with longer and richer invaluable contact with the real-word routine clinical work.

The project at the School of Medicine, DUTH involves the use of open source technologies and off-the-shelve components to deploy an integrated e-learning environment (Figure 1). This is based on a conventional e-learning platform to support pre-clinical teaching, tightly integrated with teleconferencing technology for the real-time and/or on-demand transmission from an examination room, the operating theatre or any medical laboratory (e.g. interventional radiology) to the lecture room, to enhance clinical apprenticeship and provide extended real-world experience.

The core of the deployment is an open source freely available generic Learning Management System (LMS) which provides the basic infrastructure for the management and dissemination of educational material to the Medical School and Medical Hospital Intranet, thus supporting off-line, on-demand, self-directed access to educational information and knowledge, as structured and distributed by the educators and as provided for in Web resources and local or remote medical databases. This LMS is also used to develop basic communication and collaboration mechanisms for students and teachers. An important issue in developing web-based courseware is to identify the kind and type of information that needs to be communicated in medical undergraduate education and to develop an appropriate framework for its management, and presentation so that it

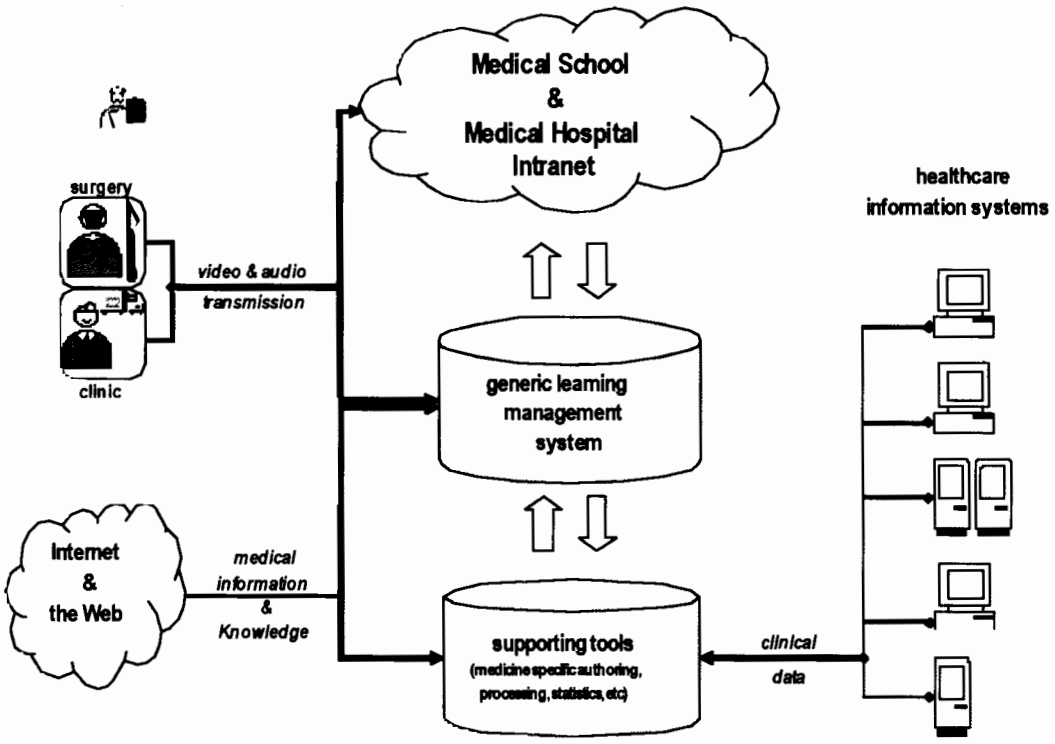

FIGURE 1
A Schematic Overview of the Integrated E-Learning Environment Deployed at the School of Medicine, Democritus University of Thrace.

can be readily used (and re-used) in generic e-learning environments. Central to this activity is the employment of the emerging e-learning standard Shareable Content Object Reference Model (SCORM, originally known as Sharable Courseware Object Reference Model). SCORM has been designed by the U.S. Government's initiative in Advanced Distributed Learning (ADL, http://www.adlnet.org) as a set of eXtensive Markup Language (XML) based specifications to define, manage, access and deliver modular educational objects so that they can be easily shared among different learning management systems.

The integrated e-learning environment includes mobile units that support video and audio transmission from remote sites within the University Hospital, for example the operating theatre or a clinic. The design allows for direct real-time transmission with backwards communication among the remote site and the lecturing theatre, as well as for real-time or on-demand web distribution via the integrated web-based LMS infrastructure.

Of major importance are research efforts to develop appropriate tools based on standard web technologies to achieve the required synergy between the e-learning environment and the healthcare information systems that provide much of the educational material. Central to this activity is to develop a web service façade for legacy healthcare information systems, in order to extract and communicate educational information using common web standards (as opposed to standards proprietary to the medical environment, e.g. HL7, and DICOM).

The web services paradigm has already gained broad industry support and is currently being introduced in biology and healthcare applications. Web services are self-contained, self-describing, modular applications that can be located and invoked over the Internet (W3C, 2004). XML is used for data presentation while messaging is described in Simple Object Access Protocol (SOAP). Web services describe themselves through a standardized Web Service Description Language (WSDL) document, and can be published to one or more Intranet or Internet repositories for potential users to locate through a standard Universal Description, Discovery and Integration (UDDI) registry. In essence, web services are a middleware technology for developing service-oriented architectures (SOAs). A SOA refers to a collection of interconnected software entities (services) that provide some capability through exchange of messages, and can be described, discovered and invoked over a network. Although web services are a recent development, the concepts underlying service-oriented systems are common to standard distributed middleware computing. Examples of earlier implementations of SOAs include the Common Object Request Broker (CORBA, Object Management Group Inc. Needham MA, USA), the Java Remote Method Invocation (RMI, Sun Microsystems Inc., Santa Clara CA, USA) and the Distributed Component Object Model (DCOM, Microsoft Co., Redmond WA, USA). However, the widespread acceptance of Internet and related technologies make web services currently the most likely middleware technology for the implementation of service-oriented systems.

Adopting an XML/SOAP web service oriented architecture for medical data management and distribution in healthcare Intranets and Extranets may have many advantages when compared to traditional system integration and/or simple web-based application interface. These include the ability to give compound structure to queries and results, handle complex tasks that require coordination of a number of disparate applications, and implement store and forward techniques.

We are currently working towards developing a cluster of collaborating web services at various levels of organization and functionality. A first tier of web services will serve as web interfaces for conventional clinical information systems, while a second tier will provide a more complex functionality suitable for data mining and knowledge extraction tasks required for educational purposes. A first implementation is a web service to retrieve medical images and related structured reports from conventional radiology image servers (Delistamatis *et al.* 2004, Delistamatis & Kaldoudi 2004). Current work involves development of added value web services that will perform more complex tasks, such as composite queries and mining of image repositories to support data collection for educational purposes. Special purpose processing and authoring tools can be fed with the clinical data collected through web services to develop concrete educational modules (e.g. radiology teaching files). Additionally, the proposed web service architecture can be used directly through the integrated e-learning environment for dynamic data retrieval during the instructional process (e.g. to explain how a diagnostic imaging data set is manipulated and reviewed in order to reach diagnosis and construct a structured report).

Discussion

To make the most out of using new technologies in medical education, there are some issues one has to bare in mind. As in every case of a paradigm shift, information and communication technologies have to find their appropriate place and way to augment medical education – mere employment of new technologies does not necessarily help,

rather introduces the extra burden to both students and teachers of having to get acquainted with additional, often unfamiliar tools and processes.

Reforming undergraduate medical education at the Democritus University of Thrace, Greece, involves the use of open source technologies and off-the-shelve components to deploy an integrated e-learning environment that will support information dissemination, facilitate knowledge extraction and communication and eventually help medical students reach an understanding of their faculty. The project addresses both aspects of medical education, namely theoretical instruction and clinical apprenticeship. In either case, the aim is to bridge and technologically integrate the academic environment, where medical information and knowledge is consumed, with the healthcare enterprise where clinical data is generated and medical knowledge is put to use. Employing commonplace, freely available Internet technologies to achieve such integration can overcome problems that may arise from healthcare domain-specific standards that are not necessarily known to developers of generic academic and educational tools. Moreover, adherence to standards to describe, manage and disseminate educational modules is important. Considering current social and economic trends, sharing educational modules among educators and across institutions may soon become commonplace, especially for exporting and financially exploiting expert knowledge.

Recent advances in information and communication technologies allow the development of a wide range of applications that support medical education. The challenge is to be creative in using this technological infrastructure as a means to mediate (not supersede) educator-learner exchanges when and where this is needed.

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