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 continue 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 Program 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


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. The 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).

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 (Liu & 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 practising and teaching in the clinical ward or several situations.**

When new technologies were 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 (Gundeman et al. 2004). Employing new technologies should just aim to support and enhance (not replace) already proven educational techniques and processes, mainly by expanding 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 (Dasepport & Panu 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 arise from the clinical practice and routine medical procedures. This major pool of medical information is as valuable nowadays as 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 most efficiently disseminate 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 aperticular 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 tools for the student to practice, together with tools that support continuous self-evaluation and mediate teacher-student exchange. Of major importance is the potential of hypertext technology to provide interconnected pieces of information, and link questions with explanations within the wider scope of a particular medical task.

The following paragraphs report 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 education and students where and when this is needed. It specifically, aims target of the project include the following:

- **provide the means so that the educator can easily combine and point to various sources of information (includ
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 the full structure and functionality of hyper-documents 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 other things addresses the problem of the often unreachable medical educators due to clinical commitments.
- 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 learning theatre using video and audio transmissions, to enhance the quality of patient care, help educators to better manage time schedule, and provide the students with longer and richer in-valuable contact with the real-world routine clinical work.

The project at the School of Medicine, DUTH involves the use of open source technologies and off-the-shelf 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 offline, 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
can be readily used (and re-used) in generic e-learning en-
vironments. 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 Reuse 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 Extensible Markup Language (XML) based specifica-
tions to define, manage, access and deliver modular edu-
cational objects so that they can be easily shared among
different learning management systems.

The integrated e-learning environment includes mobile
gadgets that support video and audio transmission from re-
mote sites within the University Hospital, for example the
operating theatre or a clinic. The design allows for direct re-

time transmission with backwords communication among
the remote site and the lecturing theatre, as well as for real-
time or on-demand web distribution via the integrated web-

tossed LMS infrastructure.

Of major importance are research efforts to develop ap-

propriate tools based on standard web technologies to ac-
hieve the required synergy between the e-learning en-
vironment and the healthcare information systems that provide much of the educational material. Central to this
activity is to develop a web service facade for legacy health-
care information systems, in order to extract and compro-

mise educational information using common web standards
(as opposed to standards proprietary to the medical en-
vironment, e.g. HL7 and DICOM).

The web services paradigm has already gained broad in-
dustry support and is currently being introduced in biology
and healthcare applications. Web services are self-conta-
tained, self-describing, modular applications that can be lo-
cated 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 de-
dscribe themselves through a standardized Web Service
Description Language (WSDL) document, and can be pub-
lished in 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 de-
veloping service-oriented architectures (SOAs). A SOA

covers 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 develop-

ment, 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 ser-
vice-oriented systems.

Adopting an XML/SOAP web service oriented architec-
ture for medical data management and distribution in
healthcare Intranets and Extranets may have many advan-
tages when compared to traditional system integration
and/or simple web-based application interface. These in-
clude 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 organi-

zation 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 extrac-
tion tasks required for educational purposes. A first imple-
mation is a web service to retrieve medical images and
related structured reports from conventional radiology im-
gage servers (Dellistamatis et al., 2004, Dellistamatis & Kal-
doudi 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 in
order 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 con-
turate educational models (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 manipu-

lated and reviewed in order to teach diagnosis and con-
stuct a structured report).

Discussion

To make the most out of using new technologies in med-
ic education, there are some issues one has to be aware 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 em-

dployment of new technologies does not necessarily help,

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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-shelf 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 and where this is needed.

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