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VIRTUAL ENVIRONMENT FOR CONTINUING MEDICAL EDUCATION

Sorana D. BOLBOACA and Lorentz JÄNTSCHI

"Iuliu Hatieganu" University of Medicine and Pharmacy and Technical University of Cluj-Napoca. Cluj-Napoca. Romania

sorana @ j.academicdirect.org

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Comment of the reviewer Maxim V. Trushin PhD. Laboratory of Pathogenesis. Kazan Institute of Biochemistry and Biophysics. Russian Academy of Sciences. Kazan Russia

Comment of the reviewer María Jesús Coma del Corral MD. PhD. Research'Unit. General Yagüe Hospital. Burgos. Spain

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ABSTRACT:

The rapid development of communication and information technologies lead to the changes in continuing medical education by offering the possibility to move up-to-date medical information through Internet to the physicians. The main goal of this study was to create a virtual space for continuing medical education. In this context, a number of computer-assisted tools for instruction, evaluation and utilization in daily activity have been developed and integrated into a unitary system. The main imposed specifications of the system were accessibility, integrity, availability, and security.

This report describes the characteristics of tables design and organization, and of system integration. The security level was imposed for assuring the accessibility of each physician to medical information useful in his or her activity and the knowledge database development.

Key words: Continuing Professional Education, Computer-Assisted Instruction and Evaluation, Medical Applications, Database Architecture.

RESUMEN:

El desarrollo rápido de las tecnologías de la comunicación y de información conduce a cambios en la educación médica continuada, ofreciendo la posibilidad dar a los médicos información médica actualizada a través de Internet. El objetivo principal de este estudio es crear un espacio virtual para educación médica continuada. En este contexto, se han desarrollado e integrado en un sistema unitario herramientas de ayuda informática para formación, evaluación y utilización en actividad diaria. Las principales aplicaciones impuestas al sistema fueron accesibilidad, integridad, disponibilidad, y seguridad.

Este trabajo describe las características de diseño y organización, y de la integración de sistema. El nivel de la seguridad fue impuesto para asegurar la accesibilidad de cada médico a la información médica útil en su actividad y el desarrollo de base de datos del conocimiento.

Palabras clave: Educación médica continuada, instrucción y evaluación asistida por ordenador, aplicaciones médicas, arquitectura de bases de datos.

INTRODUCTION

The rapid development of information and communication technologies lead to changes into the concept of medical care[1] and continuing medical education[2, 3]. An important question in this area can be "To e or not to e"?. Unequivocally, the e-phenomena (e-commerce[4], e-governance[5], e-health[6], e-learning[7], e-evaluation[8], e-pharmacy[9], e-research[10]]) opened a new era in learning, training, education and evaluation.

In medicine, there is a long path between knowledge generation and application. The knowledge translation steps can be summarized as follows: (1) generation of evidence from research; (2) evidence summary and synthesis; (3) development of clinical policy; (4) application of policy; (5) individual clinical decisions, including (a) patient's circumstances, (b) patient's wishes, and (c) evidence from research[11, 12]. Continuing medical education strategies have as main goal to short the path between evidence generation and application by introducing the last up-to-date information on medical domain of interest. The strategies applied in continuing medical education differ from country to country and are in accordance with specifications of the physician licensure maintenance. According with country specifications regarding the education options and requirements, continuing medical education could be voluntary or mandatory[13]. As in many other countries, in Romania, continuing medical education is mandatory for all specialists and the licensure must be renewed each five years[14].

The use of Internet technologies to enhance medical knowledge and performances is found in under- and postgraduate education[15, 16]. Many medical information and continuing medical education services were developed. In December 2006 where available online a number of 300 continuing medical education sites with 15744 activities and 26287 credit hours[17]. However, the greatest advantage that the Internet introduces in the medical training and education remain the access to up-to-date medical information useful in day-by-day activity[18].

Statement of the Problem

The main goal of the present research was to create an online e-training environment, blended with courses and application available to those physicians interested to improve his or her medical knowledge and abilities. The particular goals of the research were: (1) to use the advantages offered by information and communication technologies in order to develop an advanced e-training platform; (2) to create an e-learning virtual experiment on evidence-based medicine available for the Romanian physicians and medical students; (3) to bring together useful information and applications for medical decision.

The project focuses on the healthcare sector and it is addressing to the need for up-to-date medical knowledge access for physicians and medical students.

The project was focus on two cases, represented by evidence-based medicine as one topic and radiology and imaging as the second topic. The need of changes in concept and knowledge of individual decision based on best available medical evidence for Romanian medical students and physicians was the main reason for chousing the evidence-based medicine for this research. The rapid development of radiology and imaging, as devices, techniques and diagnosis tests was the reason for chousing the radiology and imaging.

MATERIALS AND METHODS

The core architecture of the system is presented in Fig. 1. The structure was constructed starting with the desire of creation an accessible, integer, available, and secure virtual environment. The versatility, flexibility and interoperability are the major characteristics of the architecture.

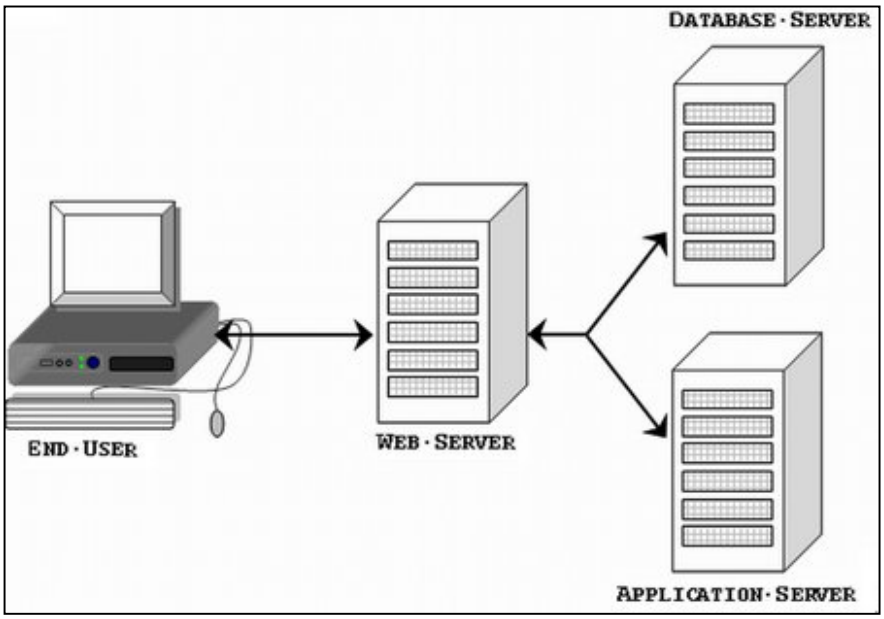

Fig. 1. System architecture

The database server provides the database management and is dedicated to data and file management. The database security ensures that date locking, consistency, and replication.

The application server store the integrated medical application improves performances, flexibility and maintainability of the system and had as major aim to centralize the process. This feature makes administration and changes management as easier as possible.

The web server is responsible for receiving the requests from the clients and generating the requested information using the services provided by the application server.

The Apache, PHP language and MySQL database server have been used in order to develop the system. Apache is a popular Web server freely distributed, being known as offering application stability[19]. Most frequently is used under UNIX platform (BSD, Linux, and UNIX) but could be used by under platforms too[20]. PHP (hypertext PreProcessor) is a programming language used in creation of dynamic application that has interaction with databases[21]. MySQL[22] the relational database management program use structured query language, allowing a great data security by defining the type of operations that each user have on data stored into the database (create, delete, modify, query). The main advantages offered by MySQL and PHP are[23]:

- **Both are free programs;**
- **Are oriented for development of Web applications;**
- **Are easy to use;**
- **Are fast. Using them together the faster reaction for dynamic Web application are obtained;**
- **The communication between them tends to be perfect;**
- **There have been published and are available many informative materials;**
- **Both of them are open source.**

The Apache-PHP-MySQL triad proved its usefulness in development of management data applications[24] and in creation of complex medical application[25, 26].

The system was structured into two main parts: Imaging and Informatics. Three applications were integrated into Imaging: (a) an educational application (Link), (b) a diagnostic test application (BoneAge), and (c) an application for patient data analysis (DataManagement). The Informatics has two main branches (MeSH and Evidence_Based - CAT, Guidelines, and Training).

The structures of the tables according with the application are presented in figure 2 - 4.

UserAdmin
AdmId
UName *(1)*
Pass
WhatBD
…

CATSubi
CATId
UName *(2)*
Title
Data
Type
Quest
TextB

Fig. 2. CATSubi tables

The rights of creation and store information into tables for integrated applications are password restricted. The user details are stored into the UserAdmin table: identification number (AdmID), first and second name (UName), password (Pass), the application where the user has his or her rights (WhatBD). Note that the information stored in this table is used by all applications where the user had the rights to create, store and delete information.

The CATSubi was created in order to store critical appraised topics: CAT identification number (CATId), the name of the author who created the CAT (UName), the title of the CAT (Title), the date and time when the CAT was created (Data), the type of standardized model use for creation (Type), the clinical question for which the CAT was created (Quest), the content of the CAT (TextB). Once a physician is register as a user, he or she name (1) will be saved into the CATSubi table when create a new critical appraised topic (2).

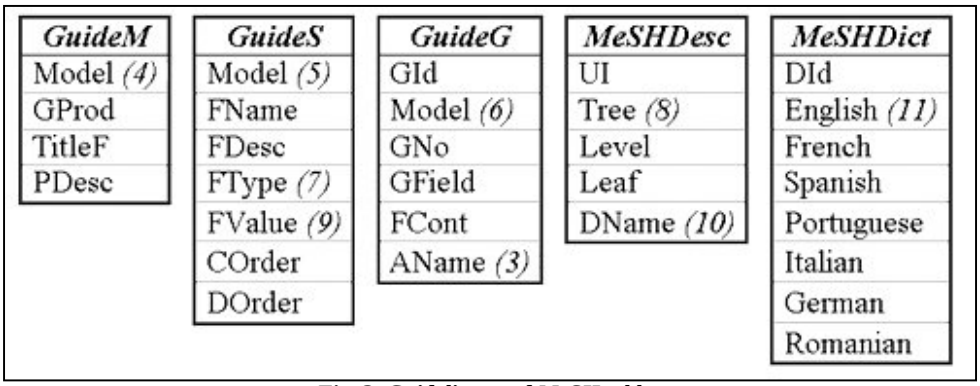

Fig. 3. ***Guidelines and MeSH tables***

The MeSH application could be seen as an individual application but also was used as indexing keyword by Guideline application. Two tables that related with each other were created for MeSH application. The name of the descriptor stored into DName (10) from MeSHDesc table is taking over by the English (11) field from MeSHDict table.

The Guideline application had three tables: GuideM, GuideS, GuideG. The GuideM table stored the basic information for a standardized model; the GuideS table the detailed structure of the standardized model and information about the type of the content that must be stored into each field, while GuideG table the clinical practice guidelines. The Model filed contains the abbreviation of the guideline model and it is first introduced into GuideM table (4). This information is used into the GuideS table (5) each time when a new standardized guideline is created and respectively into the GuideG table (6) each time when a new clinical practice guideline is created. The name of the author (UName) who creates the clinical practice guideline from the GuideG table (3) is taking from the UserAdmin table (1). In Guidelines application was predefined two types of fields: free text field – 0, and chousing one or more than one option from a predefined list - 1). When the type of field (FType) from GuideS table is 1 (7), and the list is the MeSH descriptors list, the number of descriptor (8) is store into the FValue field (9) and its name is displayed.

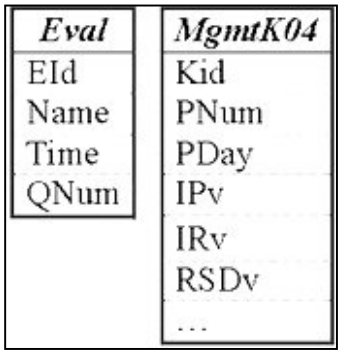

Fig. 4. Training and DataManagement tables

The Eval table was design in order to store the data from the evidence-based medicine final evaluation. Here is stored information about student (first and second name - Name), date and time when the exam was started and ended (Time) and the question ID for the forty-five questions included into the multiple choice test associated with the choused answer. This information is used for displaying the evaluation results.

The MgmtK04 table contains information about patient with kidney transplant. The users had here just the right to visualize the results of correlation between the choused variables.

PHP programs were used for creation of applications. Details about the tables and programs were previous published: creation of guidelines models and clinical practice guidelines[27, 28], training and evaluation in evidence-based medicine[29], MeSH application[30], CATSubi [31].

The virtual experiment in continuing medical education

The virtual experiment for continuing medical education and students training system incorporates distinct programs useful in evidence-based medical education, radiology and imaging education, and evidence-based decision, as well as a number of applications useful in maintaining medical knowledge up-to-date. The system is hosted on AcademicDirect domain and it is available at the following address: http://l.academicdirect.org/Medicine/

The name, functions and characteristics of the integrated programs are presented in Table 1.

Table 1. Virtual educational open system: programs functions and characteristics

Imaging		
	BoneAge	
	Aim	**Computer assisted bone-age diagnostic based on Tanner-Whitehouse method**
	Target population	**Pediatric Radiologists, Radiology – Imaging Residents**
	Characteristics	**An interactive environment which assist the pediatric radiologist in the assessment of bone age based on a hand and wrist**
		Compute in accordance with patient data and display the bone age
		Save and print the results
		Store the data in database
	Access	**Unrestricted**
	DataManagement	
	Aim	**Computer-assisted environment for analysis of relationships between ultrasonographic characteristics and biological parameters modification on kidney transplant patients**
	Target population	**Radiology-Imaging Specialists, Urologists, Family Physicians;**
		Residents and undergraduate students
	Characteristics	**One hundred and twenty-two patients**
		Twenty-six days follow up after a kidney transplant
		Eighteen variables (three Doppler Indices: pulsatility index, resistive index, systolic-diastolic ratio + transplanted kidney volume + blood serum creatinine + blood serum urea + diuresis + immunomodulatory therapy)
		Compute and display the correlation coefficients
		Calculate and display the slope and intercept(s) by applying eight regression equations
	Access	**Unrestricted**
	Links	
	Aim	**Integrated access to free journals, educational material, books, medical and radiological dictionary and dedicated searching engines**
	Target population	**Radiology-imaging residents, specialist;**
		Undergraduate medical students
	Characteristics	**Free access to twenty-fine specialty journals (Journals)**
		Sixty-six sites for educational purpose in radiology – teaching files, case reports, tutorials, (Education)
		Fourteen books (Book)
		Seven dictionaries: medical, diseases, radiology, magnetic resonance, ultrasound, radiation, radioprotection (Terms Glossary)
		Eleven medical search engines
	Access	**Unrestricted**
Informatics		
	EBM	
		CAT
	Aim	**Computer-assisted application developed in order to assist Romanian physicians in creation and using Critical Appraised Topics**
	Target population	**Romanian physicians, Romanian researchers, Undergraduate Romanian Students**

	Two different kind of users: ❍ **Physicians actively imply in creating the critical appraise topics (it is suppose that this category have high-level knowledge of English language, because almost all evidence are published in English; more, the users from this category it have insert and delete grants);** ❍ **Physicians who just use the critical appraise topic created by the first category**
Characteristics	**Assisting creation of critical appraised topics based on three standardized methodologies: assessment of a diagnostic test, assessment of therapeutic strategies, and assessment of a prognosis study**
	Computing statistical punctual parameters for each type of study according with the data included by the physician
	Computing of 95% confidence intervals by applying of an original method based on binomial distribution hypothesis
	Storing, searching, displaying and filtering of critical appraised topics. Some security levels according with the type of users were imposed for saving a new CAT and for CATs deleting
	Printing and saving a previous created critical appraised topic
Access	**Password restricted. Free registration.**
	A regular registration is required for critical appraised topics browsing, filtering, saving and printing. A special registration is required for creation and storing a new critical appraised topic or for deleting a previous created CAT (note that just the physician that creates the CAT has the right to delete it!).
Guidelines	
Aim	**Creation and management of guideline models and clinical practice guidelines**
Target population	**Assisted creation of guideline models or clinical practice guidelines;** **Physicians with abilities in formulating clinical questions, searching skills, assessment of relevance and validity of evidence.**
	Browsing, searching and using the guidelines by: Physicians, Residents, Undergraduate medical students, PhD students
Characteristics	**Assisted creation of guideline models. There were implemented four standardized guideline models (two in English and two in Romanian languages). One of the Romanian standardized guideline is an original model proposed for creation of evidence-based clinical practice guidelines**
	Assisted creation of clinical practice guideline
	Search guideline database. Nine guidelines are available at this moment into the application. There is possible to perform a strict or un-strict search.
	Display, browse, save and print clinical practice guidelines
Access	**Unrestricted for browsing, saving, printing the clinical practice guidelines**
	Password restricted for creation of new guideline model
	Password restricted for creation of new clinical practice guideline
EBM Training	
Aim	**Training, auto-evaluation and computer-assisted knowledge assessment in evidence based medicine**
Target population	**Romanian: Physicians, Resident & PhD students, Undergraduate students**
Characteristics	**Training in evidence-based medicine**
	Access to evidence-based medicine glossary of terms in Romanian language
	Access to clinical practice guideline published by Romanian College of Physicians
	Access to evidence-based articles in Romanian
	Access to CAT application
	Access to Guidelines application
	Problem-based exercises
	Self-evaluation environment
	Computer assisted evaluation
Access	**Unrestricted**
MeSH	
Aim	**Devoted to be used in conjunction with other applications.**
	It can also be use independently for browsing MEdical Subject Headings.
Target population	**Physicians, Undergraduate medical students, Researchers.**

Characteristics	**Browse Medical Subject Headings by descriptors**
	Browse Medical Subject Headings by tree
	List the Medical Subject Headings
	Translate MeSH terms from one language to another (English, French, Spanish, Portuguese, Italian, German, and Romanian)
	Use the MeSH descriptors in indexing data of medical application hosted by AcademicDirect Library
Access	**Unrestricted**

Particularities, Limitations and Possibilities

The particularity of the developed system refers the target population. By integrating applications, training and evaluation both in English and Romanian languages, the developed system complete the existing continuing professional development medical sites on one hand, and on the other hand offer to the Romanian physicians the access to medical knowledge and application in native language. Regarding the continuing medical education credits, note that, the aim of the research was not to provide credits for the training and applications integrated by the system. Our aim was to develop a system able to provide useful medical knowledge and application for voluntarily continuing medical development not for continuing medical education credits.

The Romanian College of Physicians is the forum responsible with analyzing and offering continuing medical education credits. Some criterion must be accomplished and the description of the course, the target population, the evaluation methodology and the material developed must be approved by the Romanian College of Physicians. At this stage, the system was developed and now looks to obtain the credits from the Romanian College of Physicians, and to integrate new continuing professional development modules. Note that the Romania College of Physicians[32] recognized an evidence-based medicine course for family physicians until now.

The system can be analyzed through its advantages and disadvantages. In particular:

- **The up-to-date medical knowledge is essential in daily practice. The system offer an environment where the information can be updating in a real-time as many time as it is consider opportune;**
- **The up-to-date medical knowledge help physicians to offer high quality health care services;**
- **The translation of knowledge resulted from the medical research is faster when an on-line environment is used comparing with a print journal or a book;**
- **The system integrates some medical application useful in patient management. The use of these application reduce the time spent with calculations and patient data management;**
- **The continuing medical distance learning enable just-in-time training, the physicians having the opportunity to follow the training when they consider that is necessary for their practice, and being able to tailoring the learning experience, time and place continuing medical development to personal preferences;**
- **The Romanian medical community, following the example of the European medical communities, learns to use the potential offered by on-line continuing medical education events.**

From socio-economic perspective, the benefits of on-line continuing medical development refers:

- **Up-to-date physicians that lead to the improvement of healthcare services (for society);**
- **The improvement of healthcare services lead to decreasing of the healthcare costs (for society)**
- **Less expensive options to the medical knowledge access (for physicians);**
- **Less time for staying up-to-date comparing with obtaining the medical information from a library (for physicians)**

The system can be use from technical and methodological perspective in traditional as well as in distance learning, in medicine, nursing and midwife continuing education.

Comparing with traditional continuing healthcare professional education, paper based journals, books or tutorials, the e-learning systems had a disadvantage: a computer connected to the Internet is necessary and the users must to have computer skills. For the young generation of healthcare professionals this is not a problem and for them the education in spirit of using the facilities offered by Internet in continuing professional development it is an easy job, but this education must be done. For the healthcare professionals that graduated before '90 (at least for Romania) a harder work must be done because the majority of them did not have basic computer skills.

The model used for creation of continuing medical education materials and application for physicians could be expanded and used for creation of modules specific for nursing or midwifes continuing professional development.

However, even if there are integrated educational materials are problem-based clinical scenarios and interactive applications, continuing professional development is far from completely addressed by electronic learning. Essential parts of medical profession comprise hands-on procedural skills (as is for example the transducer placement in ultrasonography, searching medical information using Internet, etc.) that are difficult to teach without real-life interactions.

Some authors sustain that even if the web-based education is highly attractive and has an important role in training and

education, in some cases it cannot replace the vital human element in medical education [33]. The social aspect of learning cannot be easily duplicated online [34] and the role of models [35] and mentoring programs cannot be over-emphasized.

CONCLUSIONS:

Continuing professional development in the twenty-one century can benefit from the opportunities offered by the development of communication and information technologies.

A Web-based learning, evaluation and medical applications in healthcare professions such as the implemented system could be a useful solution for medical knowledge free access and a shortest way in knowledge translation from research to practice.

The proposed system represents a first step forward, but the effort will be without any results if the Romanian medical community will not concentrate the efforts toward a more holistic approach to continuing professional development, to development of new training and evaluations module and of updating the existing training materials and applications.

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Comment of the reviewer Maxim V. Trushin PhD. Laboratory of Pathogenesis. Kazan Institute of Biochemistry and Biophysics. Russian Academy of Sciences. Kazan Russia

It is a very comprehensive article on application of modern education technologies in medicine. Authors described in details how the electronic education system can be created. In my poinion, authors should pay a little attention to international peculiarities - how the similar system can be used in various countries. I recommend publishing the article.

Comment of the reviewer María Jesús Coma del Corral MD. PhD. Research'Unit. General Yagüe Hospital. Burgos. Spain

The Internet has tremendous potential for the delivery of instructional materials. The advent of electronic full-text journals may improve the information access of health professionals. The timely use of accessible electronic databases, containing good bibliographic and full-text information, has the potential to assist in the maintenance of health professional competence (Marshall 1989).

We have verified that a real-time interactive distance learning, based on the availability of the Internet, is viable for providing continuing medical education. Other motivations as time, cost, or other factors, are the key to prefer a system to another one. Education on Internet, using a combination of several integrated telematic resources, being the main one the text-conference, as usually is used in the UniNet Network, is a valid and useful way for continuing medical education, which has a similar value to the traditional teaching (Coma del Corral, 2006).

The access to high-quality medical information in a specialized network as Soraca have described above, could be related to the improvements in the medical quality practice (Coma del Corral, 2005).

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