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Training of health care personnel towards the implementation and use of electronic health care records using integrated imaging technology

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Abstract. The hospital of the future will be a place in which Health Care providers of various disciplines will have access to all information about a patient in a timely fashion, and where the communication system will be able to cope with all information representations ranging through data, text, images and voice. Multimedia systems offer the facilities to cope with the specific problems of the mainly manual approach for the effective and efficient organization of information related to facts and findings in medical care. In this article we outline the training needs for future users of such systems.

Keywords: Integrated imaging technology; Multimedia; Training needs; Electronic health care records.

1. Introduction

The hospital of the future will be a place in which health care providers of various disciplines will have access to all information about a patient in a timely fashion, and where the communication system will be able to cope with all information representations ranging through data, text, images and voice. File servers, image servers, voice servers and even knowledge servers will be the essential components in the next generation of hospital information systems (HIS) [1].

The passive medical records of today's medical information systems have to change into active objects that remind, suggest, and perhaps even seek out advice. In order to accomplish this, it is important that information is presented in a focused and relevant manner. More information alone will overload the users with the only consequence being hostility towards information systems. Intelligent provision and packaging of information, tailored and formated to the situation at hand and to the individual's training and background will allow the user of the next generation of HIS to manage his or her data more effectively and turn data into useful information and productive actions.

Future users (table 1) from the health care sector should have an opportunity to learn and to be trained in the use of these systems through Computer Aided Education and through simulations. Indeed, the outbreak of advanced technology

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Table 1. Course audience

Medical doctors
Medical and administrative EDP staff
Health care assistants (nurses)
Hospital management
Health care administrative personnel
Medical and nursing students
Professional health care associations

such as WORM, INTEGRATED IMAGING, WINDOWING and other user-friendly interfaces through which interaction might become simple, does not mean that the need for any user training will disappear. The COMETT II project 'Development of advanced courseware, applying optical disk and integrated imaging technologies to the management of medical records', currently under development by the authors, will offer this opportunity, as it is felt that user's training should aim at:

(1) Introducing the new computer technology and user interface: what are the components of the system (hardware and software), how are they called, what is their function?
(2) Giving a global view of the medical imaging system (placing the user into the data flow looking at his contribution) and illustrating the context.
(3) Teaching the operation of input and output devices, functions and programs.

2. Outlining the training objectives of the project

Research on learning systems has shown that it is critical to perform task analysis in the domain under study [2]. This gives rise to a *goal hierarchy* of learning objectives in which goals and subgoals clearly and explicitly have to be defined. As students need to have a firm grasp of this goal structure, and there is no evidence that it is advantageous for them to generate goals *de novo* [3], attention has to be given to explain these objectives in the courseware. More specifically, students will have to know:

(1) How the courseware is organized, what the constituent parts are, and how these parts are to be used for achieving the final objectives.
(2) What objectives should have been reached after successful termination of the course, and of each of the modules.
(3) What background knowledge is deemed necessary to start with a specific module.

It has been stated that too little stress reduces learning [4]. However, as the opposite is evenly true, it does not make sense to invoke this stress by the lack of clearly explained procedures on such topics as what minimum amount of time has to be spent to complete each of the modules, or how to use the instruction manual, the CBT software, and the help functions and system functions. On the other hand, it is unrealistic to suppose that the audience to which the course will be addressed does not know anything about informatics. Means have to be provided to identify the background knowledge on the subject-matter of each student, and consequently to instruct users on how they can move between the different modules of the courseware following the ideal course path as calculated by the system, taking into account their background knowledge.

3. Identification of the components of integrated imaging technologies

Students should acquire *basic computer literacy*, becoming familiar with the general concepts and terminology of hardware and software in connection with imaging technology [5]. Although the necessity for this kind of information will decline rapidly as people in general become more familiar with computers, new computer technology and user interfaces have to be introduced.

A number of CBT modules will contain a description of the various technologies used in integrated imaging. Emphasis will be put, amongst others, on the manipulation, objectives, characteristics, and needs for support with respect to the devices. Details will be provided in accordance with the profile of the student (nurse, physician, hospital administrator, etc.).

As imaging systems rely very heavily on storage devices, a great deal of attention will be given to them. Specific modules of the CBT courseware will deal with magnetic storage devices, CD-ROM, LV-ROM, WORM and optical disks. Special attention will be given to basic terminology, explaining terms such as *capacity*, *trackdensity*, *performance*, *random access*, *sequential access*. The essential characteristics of the devices in terms of recording and reading capacity, performance, prices, intended use, drawbacks and advantages, etc., will be addressed. Students should also be able to identify which information in a hospital environment is suited to be stored on these media.

Document-scanners and *printers*, are important elements of integrated imaging systems too. Although it is possible to imagine a working environment where every piece of paper has been replaced by electronic means for data storage and communication within the hospital, paper documents still remain necessary to communicate with the outer world in both directions.

Students will have to be introduced into the basic characteristics of these devices in terms of performance, prices, and intended use; also, students ought to know how they have to be operated and maintained.

With respect to document-scanners, students should learn:

(1) the differences between OCR and graphic representations in terms of disk storage, future processability, etc.;
(2) the possibilities and limitations of OCR (fonts, handwritten text, etc.), graphical images and documents stored as graphical images;
(3) the meaning of terms such as *bitmap*, *graphic file formats*, *compression*, *contrast resolution*, *spatial resolution*, *pixel*, *pixel density*, *document noise* and *noise removal*, *grey scale*, *barcode;*
(4) what can go wrong when scanning documents and how different kinds of problems can be solved.

The CBT module dealing with printers will teach the students the differences between a printer and a plotter, the different types of printers available (laser, matrix, daisy-wheel, inkjet, etc.), what is meant by *landscape*, *portrait*, *printerprotocol*, *printerdriver*, *printhead*, *fonts*, *ASCII*, *cartridges*, *port*, *printquality*, *colour printing*, *halftoning* and how to respond properly to printer errors.

Students also have to learn the differences between *terminals* and *workstations* (simple, intelligent, graphical, etc.), how they are used, what is understood by terms such as terminal-emulation and *teletype*. Professionals who will be involved in the implementation of systems also need to learn how images are displayed on the screen,

how display storage requirements can be calculated, and which selection criteria can be applied.

On the topic of *networks*, trainers will learn what a network is, how it operates, what communication protocols are used, what the constituent parts are, what terms such as *LAN*, *WAN*, *server*, *workstation*, *modem*, *communication over the net*, and *resource sharing* stand for, how a hospital can be equipped with networks and how peripherals effectively can be used in a network environment.

4. Integrated imaging systems (IIS)

As soon as the student has sufficient knowledge about the various basic components of hospital information systems, he or she will have to be made familiar with integrated imaging systems (how they may be used in a hospital environment, what information can be processed by such systems, and what the benefits and drawbacks are).

Towards the installation of IIS, he or she must be able to identify realistic IIS objectives, and have a clear understanding of the importance of installing appropriate project teams when implementing such systems. The importance of setting up an analysis of the environment—building an information and process model, studying the present paper and image flow, and studying the decision process, in which an IIS is intended to be implemented—must be stressed.

This can be achieved by first introducing the student to stand-alone imaging systems, thereby demonstrating how these systems may contribute to the implementation of a paperless office and which processes can be identified in working with them, i.e. adding images (the scan/indexing process and the classification, i.e. *file building* process), retrieval of an image, deletion of an image, creation of a hardcopy of an image, and transmission of images.

In a second phase the integration of imaging systems in existing configurations will be addressed. The student will learn what the differences are between *fragmented*, *coordinated* and *integrated* information and image systems, what steps are to be taken to move from the former to the latter, and how different levels of integration may be achieved.

Finally, attention has to be given to *safety*, *security* and *responsibility* issues. More precisely, students have to know the legal impacts on keeping on electronic copy of a document instead of the original one. They should learn what can go wrong using IIS, and how catastrophes can be prevented by installing clear procedures concerning the equipment, the software and organizational aspects. They also will be instructed on basic security items and usage integrity as on how to set up a protocol for the implementation of an effective security programme on data integrity and protection of privacy.

5. Information management in health care.

In this chapter the student will be introduced to the principles of information management in health care. Different systems and configurations will be covered. Again, emphasis will be put on features which are important for the student in accordance with his profile.

Students need to have a deep understanding of how hospitals are organized in departments and functional units and how this organizational scheme may change in accordance with the type of hospital (university, general, etc.). They must be able to identify the information requirements in hospitals based on how information is

Table 2. Information systems currently in use in a hospital environment

Medical record systems
Hospital information systems
Nursing information systems
Laboratory information systems
Pharmacy information systems
Radiology information systems
Patient monitoring systems
Information systems for office practice
Bibliographic retrieval systems
Clinical decision support systems
Clinical research systems
Computer-based training systems
Health-assessment systems
Personnel information systems
Financial information systems

generated, transmitted, stored and used in this particular environment. As many hospitals are already equipped with various kinds of information system (table 2), the student must be aware of the functions they may perform, and how information from these different sources within the hospital may be integrated. Of course, he or she must be able to identify the areas in which imaging systems can play an important role.

Communication between various health care providers inside and outside the hospital environment is an important issue. Students need to know the place of other health care professionals in the health care sector, i.e. general practitioners, social security workers, insurance companies, paramedics working outside the hospital, governmental bodies, etc. He or she must recognize what kind of information is exchanged between the hospital and the other health care actors and how this information actually is exchanged between them. How ISS may have an impact on this communication must be covered in detail.

The various players in the hospital environment itself (physicians, nurses, administration, other), and their involvement in the activities of the hospital, also have to be handled. In the course, attention will therefore be given to the way in which each of these persons generates, transmits, receives and looks for information during his/her activities, to the way in which hospital information systems may have an impact on day-to-day work and how integrated imaging systems may contribute to the improvement of his/her performance as a health care worker. Indeed, medical data cannot be interpreted without considering both the health care system as a whole, and the organizational factors at work in the clinical environments in which those data are generated [6].

6. The electronic health care record (EHR)

6.1. *The paper-based medical record*

The *clinical record* is the corner stone of clinical practice, as it allows the combination of information from different sources and provides the basis for diagnostic, therapeutic and prognostic decisions. The more precise the information it contains, the more reliable the conclusions based upon these data will be.

Traditional medical-record keeping is paper-based, and a lot of procedures concerning the management of medical records with which health care providers are familiar, are designed to achieve a maximum of efficacy. As imaging systems are

based on the original paper-document philosophy, an in-depth understanding of the medical record as such, and of its constituent elements, is mandatory.

Students should know why medical-record keeping is important, what medical data may look like, what kind of information is registered in the medical record, what kind of documents are found in the paper-based medical record and how these documents are arranged in folders.

They should understand the dynamics of the paper-based medical record: how and when information may be created and updated, how the information content of the medical record changes during and after events such as registration of a new patient in the hospital, registration of a patient in a department or a functional unit, admission or discharge of a patient, and who is involved in these activities. Of course, the responsibilities of the various health care providers in handling the medical record should be outlined, and finally the pro's and con's of paper-based medical record keeping in a hospital environment. This must be achieved by first demonstrating what features and requirements are fundamental for an efficient filing system, and second in what aspects the paper-based medical record meets or does not meet these requirements, by specifying the current deficiencies of the paper-based medical record at different levels in the organization: the hospital level, the department (folder) level and the document level.

6.1. *Modes of implementation of an EHR*

An EHR, even based on imaging techniques, can be designed in many different ways. In order to make students aware of the various possibilities and the pro's and con's associated with them, students must be instructed on the differences between data-oriented versus document-oriented, and centralized versus decentralized approaches in EHR design. Then they have to be instructed on the primary functions that can be provided by computer systems in a health care environment and which of these functions are covered in an EHR. Finally, more detail will be given on the concept of electronic documents, how they are organized and identified, what their constituent parts are, and how to identify the basic elements of an EHR architecture, based on document imaging.

After having been introduced to the proposed architecture for EHRs based on integrated imaging techniques [7], students will be trained in medical record management by simulating a real environment. This approach has the advantage that students are faced with a simplified version of reality, whereby the complex system is abstracted to its most important elements. The topics that need to be addressed are the creation, updating, consultation and archiving of medical records. Details associated with these issues are outlined in table 3.

EHRs should be interfaced with other information systems. Therefore, students have to be instructed on how this integration may be realized. Special attention has to be given to integration with laboratory information systems, order-communications, financial and accounting systems, devices for data capture, departmental information systems and scientific applications (research and statistics). The importance of standards needs to be explained.

Concerning *security aspects*, students should know about *authorization, authentication, usage integrity, data and program integrity, availability, non-repudiation, electronic signature, encryption, level of security, audit trail.* They must be able to identify possible safety and security problems and their possible causes, how to evaluate the level of security of a given system and what measures have to be

Table 3. Important issues related to the management of electronic health care records

Creation of an EHR
Which procedures are to be followed by the user and the system when creating a new medical record?
Why is an unique patient-identifier for the entire hospital important?
How may indexing and keywords be used for later retrieval of the EHR?

Modifications and updates of EHRs
How may data in an EHR be updated?
How may the system keep track of updates and what implications does this behaviour have on security?
How may EHR systems handle version-updates of information?
What are the user's responsibilities when:
adding new data to an existing record,
modifying existing data in the record,
deleting existing data,
archiving?
How must EHR systems manage situations in which several users are manipulating the same record at the same time?
What do we mean by *data-capture*, *data-input*, *error-prevention*, *consistency*, *controlled vocabulary*, *coding*, *classification?*
How are updates of an EHR related to episodes, encounters, activities and specialists?

Consultation of EHRs and document generation
What is understood by *querying*, *surveillance*, *menu*, *pull-down menu*, *commands*, *query-by-example*, *macro-language*, *fill-in-the-blanks system*, *client-server technology*, *database*?
What are the different kinds of indexing and search techniques and methods?
How many different techniques of interfacing the user with the system have an impact on issues such as learning rate, ease of use, and expandibility?
Why is in a multi-user environment what is on the screen not necessarily the most recent information?
How are hard copies of documents generated?

Archiving an EHR
What is archiving needed, thereby focusing on the problems of maintaining very large databases over a very large timespan: performance, safety measures, changes in coding systems, comparability of technical information after the introduction of new methods, statistics, etc.?
How may archiving procedures of EHRs be set up?
When may an EHR be archived, and what consequences does this have on the availability of the data?

undertaken at various levels to prevent the identified problems. Also, they need to be aware of the present situation and future trends of the legal coverage of the European Community on safety, security and confidentiality with respect to health care records.

7. Organizational and implementation-related issues

The purpose of this part of the course, especially for those people being involved in the implementation of the new technologies in a hospital environment, is to provide indications on how to create a framework for the development and the maintenance of the new organization and technological infrastructure.

In a first phase, students should be made aware of the prerequisites towards the installation of such a system: how should they investigate the present environmental and organizational situation, including the decision process? How can they evaluate the organization's information strategy, the information system plans and the technological infrastructure? How will they estimate the management's awareness and willingness towards new technologies, and what about organizing internal 'selling' to management? Finally, they need to learn to evaluate the availability of knowledge and experience, of hardware and software, and the use of information system development methods, techniques and tools.

They also must be able to deal with the impact the proposed technology may have on the health care organization. They must be trained in how to propose organizational changes, alter existing functions and describe new functions due to the introduction of new technologies, as well as how to organize 'selling' to all levels of the organization and training.

Methods and techniques for the implementation, as well as implementation scenarios, have to be covered in detail. Therefore, students will have to know:

(1) a shortlist of methods, techniques and tools that could be used when introducing new systems and new technologies;
(2) how to adapt available methods to the specific requirements and, if necessary, develop alternate methods and scenarios;
(3) how to plan the development and introduction of new technologies, longer-term plans and operational plans;
(4) how to use techniques important to the introduction of imaging technology: document flow analysis and information analysis;
(5) alternative ways of developing systems with regard to level of knowledge and experience, availability of competence, hardware and software, networking, etc.

Finally, they must be provided with recommendations on how to make a budget for the development and introduction of new technologies, how to perform cost/benefit analysis, how to organize the project team(s) and ways to manage the project (plan, organize and control), how to provide for the integration with existing systems and organization (e.g. interfaces and possible conversions or changes).

8. Conclusions

From a scientific point of view it is the common opinion that in hospital information systems the emphasis should now be on the medical applications, since health care providers till now have been underserved. In this context it has to be stressed that the medical record is the single most important tool within a patient care system. Within a few years the traditional paper-based medical record will be replaced by electronic systems, eventually based on integrated imaging techniques. In order to provide health care providers in the broadest sense with the necessary knowledge, in-depth understanding of the possibilities of these systems has to be provided.

The proposed training programmes combine practical drill in the manipulation of HIS with explanations of the mental scheme standing behind the new instrument. This combined approach has been recommended on various occasions. The *skills-only* approach to training leads to users becoming dependent on the support of a HIS expert when problems occur, while focusing on the cognitive aspects of learning the subject-matter provides students with a deep insight into the functionality of the system within the overall framework [8].

The CBT modules will give each trainee the opportunity to operate the computer on a test copy of the main functions of a prototype HIS. The authors are convinced that simulation of personal computers is the almost ideal way of training in such a matter.

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