



ORIGINAL PAPER

# On-line integration of computer controlled diagnostic devices and medical information systems in undergraduate medical physics education for physicians

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**Abstract** We designed and evaluated an innovative computer-aided-learning environment based on the on-line integration of computer controlled medical diagnostic devices and a medical information system for use in the preclinical medical physics education of medical students. Our learning system simulates the actual clinical environment in a hospital or primary care unit. It uses a commercial medical information system for on-line storage and processing of clinical type data acquired during physics laboratory classes. Every student adopts two roles, the role of 'patient' and the role of 'physician'. As a 'physician' the student operates the medical devices to clinically assess 'patient' colleagues and records all results in an electronic 'patient' record. We also introduced an innovative approach to the use of supportive education materials, based on the methods of adaptive e-learning. A survey of student feedback is included and statistically evaluated.

The results from the student feedback confirm the positive response of the latter to this novel implementation of medical physics and informatics in preclinical education. This approach not only significantly improves learning of medical physics and informatics skills but has the added advantage that it facilitates students' transition from preclinical to clinical subjects.

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## Introduction

The contemporary education of medical professionals has become more complex as a result of advances in medical devices and information technology whilst accurate diagnosis and adequate therapy is not possible without a high level of technical support [1–3]. Information and communication technologies such as medical information systems (MIS),<sup>2</sup> radiology information systems, laboratory information systems and hospital information systems have become necessary for fast and effective medical data manipulation, processing and storage. Medical faculties need to provide students with the necessary learning opportunities to facilitate and accelerate their familiarization of this new highly technological clinical environment [4–6]. At our faculty, we have included a MIS in the laboratory curricula of all preclinical courses where this is appropriate. Hence, in their medical physics laboratory sessions, students use diagnostic devices which are connected on-line to the MIS to simulate everyday tasks in a modern primary care clinic. The information system supports direct transfer of all types of data (textual, numerical, graphs, images) and their subsequent processing, manipulation and storage.

## Laboratory classes as simulated clinical medical examinations

The practice of medicine includes a range of disciplines, knowledge, skills and competences. Medical professionals need to be able to address complex situations effectively, take correct decisions and interact with patients in a holistic manner. One of the important goals in medical education is therefore to emphasize the relationships and the connections among the different medical disciplines [7,8]. Practical classes include a considerable number of examinations targeted at the measurement of basic body functions. In clinical practice, the results of these examinations are the foundations on which the final diagnosis is reached. Such examinations are nowadays supported by many complex measuring and imaging devices and the student is expected to be able to understand not only the significance of the medical results but also the functioning of these devices in order to be aware of their technical limitations and the factors influencing their safe use. This is a crucial educational component of contemporary physics curricula for the medical and healthcare professions [9,10]. In hospital practice data from the devices is acquired, stored, processed, and linked to personal patient data and available throughout the hospital. To simulate this clinical environment within the educational laboratory a system with the following technical, software or role specifications is therefore required [11,12]:

- All measuring devices used in laboratory classes need to be computer interfaced and data of various types (textual, numerical, images, graphs) digitized and automatically transferred to an MIS.

- During each laboratory exercise every student assumes both the role of examined and examining person (virtual patient and physician, respectively).
- Each practical exercise represents a 'medical record' in the student's folder (in his role as a patient) stored in the MIS. The medical record may accept all forms of results from measurements as attachments and conclusions from measurements are presented as 'medical reports' which are also stored in the student's medical record.
- A student's medical reports are in the form of Excel sheets with automatic checking of results before they are sent to the MIS.
- Each 'medical record' in a student's folder contains date, time of creation, and electronic signature for ease of checking and evaluation.
- All 'medical records' are handled in accordance with data protection systems as required by law and access is restricted according to the privileges of the different users (students and teachers) and the written consent of individuals.
- A study group (approx. 30 students) represents the number of patients in one clinical session as well as the number of medical professionals with the right to practice in that session.
- Teachers are in the role of heads of these medical offices with corresponding access rights to be able to evaluate students' activities.
- The MIS operates within the local faculty computer network and is easily accessible to students and teachers from workstations in all computer rooms, labs, and offices of teachers.
- Instructions for laboratory classes are available on-line in the form of interactive e-learning courses in the LMS (Moodle).<sup>1</sup>
- A student's folder in the MIS contains all records from all subjects taught during the entire preclinical period of medical study (typically 3–4 years).

## The computer-aided-learning environment

As the environment and background platform for our computer-aided learning and practical training, we chose a partially modified version of the commercial MIS PC Doktor, which is routinely used in outpatient departments in our country. The system enabled us to organize the structure of our laboratory sessions to mimic the structure of work at outpatient departments thus simulating the handling of authentic medical data. The MIS database can be used as a storage site which enables students to save their results in accordance with the standards for medical data manipulation and storage. It also makes possible the comparing and sharing of results of examinations taken within various subjects and in different study years. We simulate the clinical management of the patient's medical documentation which involves textual records created with the integrated text editor and structured data records from

<sup>1</sup> Learning Management System (LMS) – An environment for interactive computer-aided learning.

<sup>2</sup> Medical Information System (MIS) – An environment for the management of medical care and the administration of electronic medical documentation used by medical professionals.

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