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# *eduCRATE*- A *Virtual Hospital* Architecture

# Lăcrimioara STOICU-TIVADAR<sup>a</sup>, Vasile STOICU-TIVADAR<sup>a</sup>, Dorin BERIAN<sup>a,1</sup>, Simona DRĂGAN<sup>b</sup>, Alexandru ŞERBAN<sup>a</sup>, Corina ŞERBAN<sup>b</sup> <sup>a</sup> Politehnica University of Timişoara, Romania <sup>b</sup> Victor Babeş University of Medicine and Pharmacy Timişoara, Romania

**Abstract**. *eduCRATE* is a complex project proposal which aims to develop a virtual learning environment offering interactive digital content through original and integrated solutions using cloud computing, complex multimedia systems in virtual space and personalized design with avatars. Compared to existing similar products the project brings the novelty of using languages for medical guides in order to ensure a maximum of flexibility. The *Virtual Hospital* simulations will create interactive clinical scenarios for which students will find solutions for positive diagnosis and therapeutic management. The solution based on cloud computing and immersive multimedia is an attractive option in education because is economical and it matches the current working style of the young generation to whom it addresses.

Keywords. Virtual Hospital, eLearning, cloud computing, medical guidelines.

## Introduction

Simulation is a technique for practice and learning that can emulate and amplify real experiences with guided ones, often "immersive", that evoke or replicate substantial aspects of the real world in a fully interactive fashion. Simulation-based learning can be the way to develop health professionals' knowledge, skills, and attitudes, whilst protecting patients from unnecessary risks [1, 2]. Simulation-based medical education (SBME) is becoming a powerful force in addressing the need to increase patient safety through quality-care training. Recognizing the benefits of SBME, increasing numbers of bodies involved in medical and health care education and training are establishing simulation centres worldwide [1, 3]. In classical medical education many students feel the difference between the class versus clinical environment, considering that they are inadequately trained in management of physical examination, and diagnosis. Medical simulation is proposed as a technique to bridge this educational gap [4], allowing the enhancement of several skills: technical and functional expertise training, problemsolving and decision-making skills, interpersonal and communications skills or teambased competencies, but applying the "*primum non nocere*" principle, as well.

Recent advances in educational technology are offering an increasing number of innovative learning tools, as the use of virtual 3D worlds, also known as *Virtual Immersive Environments* (VIEs). The advantages of using VIEs for learning include: (i)

dorin.berian@upt.ro.

Practicing real world skills with rich feedback in a safe environment that does not impact real processes or persons; (ii) Mastering a technique, behaviour or method through guided rehearsals again and again as many times as is needed; (iii) Ability to practice in the virtual environment not accounting location or time, only having access to a computer [5]. There are several approaches regarding implementing and using the virtual hospitals. The most frequently used solutions are online virtual worlds like *Second Life* and *OpenSim*. Using an *avatar* one can visit places in virtual worlds and socialize with others (see Figure 1). *Second Life* allows developers to personalize the virtual worlds and add some interactivity by using *Linden Scripting Language*.



Figure 1. Example of Virtual Hospital in Second Life

Another popular way to develop Virtual Reality (VR) applications is the use of game engine platforms like Unity3d [6] or Unreal Engine [7], where virtual environments are created together with their own interaction models between users and virtual elements. Several of the most popular virtual hospitals worldwide are: *Virtual Hospital* from the *Imperial College of London* [8], *Virtual Hospital* from University of Brighton [9], simulators from Keele University [10] and Inmedea Simulator [11].

Currently in Romania there are no advanced VR software solutions applied in medical education. The *eduCRATE* project (*education* + Hippo*CRATEs*) proposes a *Virtual Hospital* representing a virtual learning environment providing medical students the opportunity to simulate situations encountered in the medical practice. This project suggests several technological novelties, as presented in the followings.

#### 1. Method: requirements, roles

The *eduCRATE* project will issue a complex information system for management and development of interactive multimedia content that supports modern and qualitative medical education for cardiology and urology disciplines, based on scenarios using *avatars*, helping students to train on a casuistry extracted from the real world. 3D models will be provided for patients, students, consulting rooms, tools, devices, medical equipment etc. that will provide a virtual space for simulation of medical activity. Interaction in terms of medical information will be based on guidelines and medical scenarios and on the *Electronic Health Records* (EHR) of patients. The solution based on cloud computing and multimedia is an attractive option in education because it matches the current working style of the young generation whom it is addressed. The solution is economical, too: the infrastructure is provided scalable, depending on the actual needs and thus relieving the institutions from the burden of purchasing and maintaining it.

The *eduCRATE* project suggests an absolute novelty for this kind of applications: the use of medical protocols and guidelines, by using a standard representation language. Compared with previously presented solutions, which run fixed scenarios, *eduCRATE* proposes to perform simulations following a set of scenarios defined in an external database, according to medical protocols and guidelines. Such scenarios may be added or modified anytime, giving to the project more flexibility compared with previous solutions, and can easily be adapted to any clinical scenario.

Medical students are the end users of the system: they will interact with virtual patients, will collect the medical history and will review clinical symptoms, laboratory tests and imaging investigations, and will receive suggestions for possible diagnostics (differential diagnoses) in a complex VR environment. The students should consider these suggestions, choose the best option and interpret it (i.e. positive diagnosis).

Information is needed to define scenarios implementation and to manage their associations with the students. Thus the system is "fed" with the necessary information, interacting with four different types of users, these actors playing different roles:

- The medical guidelines developers that implement, using standardized representation and specific software environments, the medical scenarios.
- Representations editors of VR the multimedia specialists that define/design/edit these representations which form the VR in which the medical students will be immersed for training and/or examination.
- Administrators of patients' medical data are medical academics that will introduce in the system medical records of the patients, fictitious or specially designed for this purpose, to build casuistry designed for educational purposes.
- Administrators of didactical activity academics that assign various scenarios to the students: customize the training, implementing complex interaction scenarios (where in cyberspace "meet" and interact more students and possibly professors, around a virtual patient), define tests, allocate them to the students and assess the results reports.

The system will offer functions like:

- Creating and managing flow representations of the clinical process (medical guidelines) using dedicated representations and environments, like *Clinical Decision Support Systems* (CDSS).
- Creating and managing patient medical information according to different medical cases, necessary for training and evaluation processes, using an EHR system, also including importing data facilities.
- Building VR models needed to accurately and completely represent the proper interaction of the clinical process.
- Providing an integrated service to individually access the virtual space enabling the simulation of the patient-student interaction.
- System administration, including generating specific reports.

## 2. Results: a new System Architecture

The system is built in a modular manner to facilitate reconfigurations and updates. The proposed system architecture for this project is presented in Figure 2.

The interaction with students is done through their immersion in a VR environment in which themselves, represented by *avatars*, examine virtual patients, accessing the EHR containing demographic data, medical history, previous visits, laboratory tests, imagistic investigations, ECG, treatments, with the possibility to react on the available



Figure 2. The eduCRATE Virtual Hospital System Architecture

information through decisions, additional requests, different virtual treatments applied like being a real doctor.

The representations will respect the frame of well-known standards or templates:

- The VR environment was selected to be one well-known and spread, which can be easily used to allow importing 3D models from other similar environments. For the project we are considering several development platforms for VR environments, of which *Unity 3d* distinguishes for its features.
- EHR will have a similar specific structure met in common hospital information systems, but importing data from any source of medical data will be considered, using the interoperability standard HL7-CDA [12].
- The decision scenarios for the medical act will be represented internally by specialized languages standards [13, 14, 15, 16]; ARDEN syntax was selected.

The Integrator itself will be developed in C#. The synchronization between components is done by messages. Infrastructure issues are solved using the economic solution of cloud services; this simplifies the role of the professors in the medical universities; thus they do not have to buy/build/manage IT infrastructures, because these concerns are transferred to the cloud provider. Thus, the solution becomes very easy to extend, any new entity can be virtually connected to services, with the consent of the owners of the solution.

# 2.1. Conclusions

This paper presents a new learning method and environment, with original features, that uses technology, for a real need to train future doctors, to stimulate associative thinking and decision-making. As a result, a new Software System Architecture, based

on cloud computing technologies, medical guidelines representation, 3D immersive virtual reality, and electronic health records, is described. This system is not replacing a medical professor, but provides support required by the younger generation, constituting itself as an innovative way of education in medicine. Evaluation of learning outcomes compared to conventional methods will provide reasons for widespread introduction of this type of training, by curriculum restructuring and student-centred learning. Using this *Virtual Hospital* application, the "*primum non nocere*" ethical imperative will provide the framework for medical training at the highest standards, for patient safety and error management. The novelty of the approach is given by the flexibility offered by integrating the medical guidelines and the EHR, in contrast with the current relatively inflexible solutions.

From the educational point of view the project will provide a new and modern learning environment, in a realistic approach, engaging and dynamic, that includes a wide range of medical cases. From the medical point of view the new *Virtual Hospital* application will facilitate clinical practice training without exposing the patients to any risk. Exercising various clinical scenarios, the students can improve their timing and skills. This can prepare them for future real clinical situations.

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