Abstract: In this paper we present the modeling process of a collaborative virtual environment for medical e-learning. The goal of this research is to allow medicine students to simulate a medical consultation on a virtual patient, using the current pedagogical methods based on clinical cases and integrating web technology methods. The environment is composed of a set of cooperative platform independent tools that allows students to simulate a consultation at distance on a virtual patient that can be designed easily by the teacher. Using multimedia data exchange, the simulation is more realistic than a face-to-face simulation. Information can be shared between students and teacher in multimedia various forms like text, audio, video, and whiteboard.

Keywords: E-learning; Virtual Environment; Virtual Patient; Computer Supported Collaborative Learning (CSCL); Medical Training; Case-Based Learning (CBL).

1. Introduction

E-learning is the use of Internet technologies to enhance knowledge and performance. E-learning technologies offer learners control over content, learning sequence, pace of learning, time, and often media, allowing them to tailor their experiences to meet their personal learning objectives. In diverse medical education contexts, e-learning appears to be at least as effective as traditional instructor-led methods such as lectures. Students do not see e-learning as replacing traditional instructor-led training but as a complement to it, forming part of a blended-learning strategy. A developing infrastructure to support e-learning within medical education includes repositories, digital libraries, or virtual environments. Innovations in e-learning technologies point toward a revolution in education, allowing learning to be individualized (adaptive learning), enhancing learners' interactions with others (collaborative learning), and transforming the role of the teacher. The integration of e-learning into medical education can catalyze the shift toward applying adult learning theory, where educators will no longer serve mainly as the distributors of content, but will become more involved as facilitators of learning and assessors of competency.

In this paper we present a new model of collaborative virtual environment for medical e-learning, this model is based on virtual patient methodology. The virtual patient provides a semi real environment which can be used for students training and assessment. The teacher will be able to create a medical case represented in a virtual patient, which can be hardly achieved in the real time. These medical cases can be accessed through a web based application that provides a set of interactive multimedia tools that can be used in diagnose any virtual patient. Either in training mode (lectures) which can be recorded and accessed later by medicine students, or in assessment mode which enables the teacher create a virtual practical assessment. Collaborative e-learning is most suitable for clinical case-based learning, which provides a set of communication tools between teachers and students like whiteboards, audio, video, and textual communication.

In the following sections we present the problem of clinical case-based learning. Then we introduce the virtual patient model, its modes, and its standard data specifications. Later we present our model and its proposed
functions.

2. Clinical Case-Based Learning
Developing a repository of interesting clinical cases that illustrate various aspects of clinical learning. These might include:

- Case notes/extracts from a case history.
- Investigations carried out and the results, X-rays, etc.
- Reports written by other health professionals.
- Examples of letters (referral, discharge, follow-up).
- Video or audio tapes of patient encounters.
- Extracts from relevant articles about the clinical condition, treatment options, etc.

These cases can be used as stimulus material to encourage students or trainees to learn about a specific clinical condition [1]. It is seen as interesting and relevant by learners and allows the teacher to pre-select material which illustrates specific learning points, because the material is based on real patients and real resources.

The main goal of medical education, however, is still to produce professional physicians. The new paradigm is based on the “Learning by doing” idea, which is principally based on clinical cases. Problem-Based Learning (PBL) is used during preclinical courses and Clinical Reasoning Learning (CRL) is the adaptation of PBL for clinical courses [2]. The main difference between these methods is that in PBL students analyze clinical cases in several sessions in order to identify the problems and pedagogical subjects for solving the problem; in CRL students simulate a medical consultation to obtain the diagnosis, in only one session.

Clinical Reasoning Learning (CRL) is a pedagogical method based on real patients’ problems [3]. The teacher will be able to create a virtual patient with specific medical case properties. Then the teacher can simulate a virtual diagnosis, broadcasted to students. Or a group of students can simulate the diagnosis. The teacher helps, corrects and coordinates the students during the simulation.

3. Virtual Patient
Virtual patients allow the learner to take the role of a health care professional and develop clinical skills such as making diagnoses and the correct decisions. The use of virtual patient systems is increasing in healthcare education, partly in response to increasing demands on health care professionals and education of students but also because they allow opportunity for students to practice in a safe environment. There are many different formats a virtual patient may take. However the overarching principle is that of interactivity - a virtual patient will have mechanisms for the learner to interact with the case and material or information is made available to the learner as they complete a range of learning activities. A number of different modes of virtual patient delivery have been defined [5]:

- Predetermined scenario [directed mode]
  - The learner may build up the patient or case data from observations and interactions [blank mode]
  - The learner may view and appraise or review an existing patient or scenario [critique mode or rehearsal mode]
  - The VP may be used as a mechanism to address particular topics [context mode]
  - The learner may use a scenario or patient to explore personal/professional dimensions [reflective mode]
  - Banks of patients or scenarios may collectively address broad issues of healthcare [pattern mode]

Virtual patients increase the availability of training opportunities for medical students, making them less dependent on actual cases to learn how to handle different situations. Unlike real patients, virtual patients can be accessed on demand and they can be endlessly replayable to allow the user to explore different options and strategies. They can be structured with narratives that represent real situations while challenging the user with a wide range of tasks[6]. Despite their efficacy virtual patients are still a tangent and prosthesis to reality. They should be viewed as augmenting existing modes and methods of clinical teaching.

The Virtual Patient Data (VPD) provides the personal and clinical data that is relevant to the clinical scenario being simulated. The VPD is a bit like a clinical chart, containing data elements and some structure that corresponds to the medical history, physical examination, laboratory and radiology data, and procedure and outcome data.

The VPD architecture should be designed to enable a flexible approach to how this data is expressed and managed.
The Virtual Patient schema includes the following data elements. In most cases, these elements contain sub-elements [7].

- **Virtual Patient Data**: is the root element. It contains elements that provide clinical and demographic data for a virtual patient as well as metadata.
- **Patient Demographics**: a sub-element that contains sub-elements that define the name, age, sex, and other demographic characteristics of a virtual patient.
- **VPD Text**: a sub-element that provides narrative or other descriptive text that is part of the virtual patient data.
- **Medication**: a sub-element that describes a medication taken by the virtual patient in detail.
- **Interview Item**: a sub-element that contains sub-elements that describe a single question and response.
- **Physical Exam**: a sub-element that contains sub-elements that describe a single physical exam and the findings of that exam.
- **Diagnostic Test**: a sub-element that contains sub-elements that define test results.
- **Diagnosis**: a sub-element that defines either a differential diagnosis or an author diagnosis meant to be the final diagnoses intended by the virtual patient author.
- **Intervention**: a sub-element that describes a single intervention.
- **Organization**: a sub-element that contains sub-elements that create a hierarchical structure for the other virtual patient data elements. This hierarchy can then be used by authoring systems importing the data.

4. **Model**

After observing some face-to-face CRL sessions and based on our experience on the designing of learning environments in other domains. We wanted to create a Virtual Environment that could be used for E-Learning. There is no a general method for collaborative virtual environments; we used the following methodology: at first, we identified the users and their roles. Next, we listed all the tasks for each role, which is partially described in this paper. After that, we created an UML model. Finally, we identified the main functionalities of the model and the computer tools that will be used.

- **Identification of roles**: three types of users are identified: teacher, student, and physician.
- **Task per role**: teacher will be able to create virtual patients with different medical conditions. These medical conditions could be blood pressure, X-Ray, patient’s complaints, etc. then he can play the role of the physician by examining this patient online, this examination will be broadcasted live to students. Students can ask questions, teacher can explain something on whiteboard. A CRL session can be attended online. Students can also play the role of physician in a collaborative form, they can work together, perform diagnosis, write notes, or ask each other. Teacher will monitor this diagnosis, help, or assess the students.
- **Use case model**: based on the user’s description below, we created a UML diagram for the lecture model shown in Figure 1 and the collaborative diagnosis and assessment shown in Figure 2.

Main functionalities: the proposed model should enable the following functionalities:

- Create a Virtual Patient: The teacher should be able to create a virtual patient, by setting the patient properties, upload pictures, or sounds.
- Complementary Exams and Medical Record: In order to enrich the medical simulation, we can use some multimedia data, principally medical imagery or photographs. These documents are used to complete the exams and medical record. The images should be physically stocked on the local web server and their URLs on the database. The patient selects a clinical case, the list of associated documents is updated. He/she can select the documents, and they are sent to all users. Some modifications can be made on images, for example physicians can zoom in/out of them or, write and draw annotations on the images. These annotations can be consulted by other users.
- Physicians’ notes: Physician’s notes can be consulted by all group members. The teacher can evaluate their reasoning and send immediately feedback. Thanks to these electronic applications, physicians can compare their notes with
other physicians’ notes. This comparison allows the students to make a self-evaluation and they can learn from their mistakes.

- Physical Examination: Pictures and body sounds are used to simulate the physical examination. The patient can have some pictures and sounds in the database. In order to make patient-physician communication easier at distance, a human body image is used to indicate the problems area, for example, the physician can click over the image to ask patient if the area is painful.

- Documentation Access: In order to facilitate the learning process, external resources can be used by students during the session. These resources include e-books, commented or interactive clinical cases, medical images, multiple-choice questionnaires, medical guidelines, medical encyclopedias, human atlases, medical digital libraries and computer-assisted diagnostic systems. The teacher can recommend some sites for consultation.

**Computer tools:** to develop this model, we need a Web Server to stock pedagogical documents and local decision-making systems; a relational database for indexing the local and external resources, a chat server to mediate the user communication, a web browser for accessing pedagogical resources, a sound player to listen to body sounds, and finally, some cooperative tools for sharing information like a graphics whiteboards and a cooperative notepad.

### 5. Conclusion

Medical e-learning based on CRL is currently used in medical schools throughout the world. Unfortunately, the computer support systems available are not adapted for multi-users, and don’t have immediately teacher feedback. Our objective is to create a computer tool to allow medical e-learning in collaborative form. In this paper we have described the main stages of the modeling process in this collaborative virtual environment for medical e-learning. We chose Clinical Reasoning Learning as a pedagogical role-play format method. Model shall provide extra functionalities that are not used during the face-to-face simulations. And we chose Virtual Patient as design and implementation model for applying the CRL. Multimedia data allow students to have a more realistic representation of the patient problem than can be represented by a virtual patient. The electronic notepad allows the tutor to assess and send feedback. It also allows information to be shared and compares physicians’ notes. In the near future, we plan to include other technologies like virtual reality or teleconferencing into this research.

### References


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**Figure 1**: Use case diagram for lectures.

**Figure 2**: Use case diagram for collaborative diagnosis and assessment.