Virtu@l Consult@tion: an Interactive and Multimedia Environment for Remote Clinical Reasoning Learning in Cardiology

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Abstract

The medical curriculum has changed with the adoption of the student-centered and case-based learning paradigm. Information and Communication Technologies can be useful tools to complement Clinical Reasoning Learning (CRL) sessions. Our objective was to use computers in order to coordinate remote CRL sessions, integrating electronic resources at every step of the reasoning process. CRL sessions will be enriched by multimedia medical data.

We created Virtu@l Consult@tion *a Computer-Supported Collaborative Learning environment for CRL sessions. It can be used for undergraduates, internships, residency or continuing medical education at distance. It can also be useful to prepare physicians for telemedicine technologies.*

Keywords: *Distance Learning; Patient Simulation; Telemedicine; Cardiac Imaging; Medical Informatics.*

1. Introduction

During the last 30 years, the medical curriculum has changed in universities, with the adoption of the student-centered, situated and case-based learning paradigm. This paradigm includes Problem-Based Learning (PBL) [1] and Clinical Reasoning Learning (CRL) [2] methods. CRL is a pedagogical method used in order to develop and improve students' clinical reasoning and problem-solving skills.

Information and Communication Technologies (ICT) are currently used in medical education [3]. However, ICT are not completely integrated in medical education but used as optional support after courses. We consider that they can be useful tools during on-line CRL sessions.

Owing to training periods for medical students in remote hospitals, organizing face to face CRL sessions is not easy. On-line sessions have become essential and could be used more and more frequently.

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Our objective was to use computers in order to coordinate remote CRL sessions, integrating electronic resources at every step of the reasoning process. First, this allows teachers and students to simulate medical teleconsultations. Secondly, this enables the use of multimedia data making this simulation more realistic than a traditional face-to-face CRL session.

We created "*Virtu@l Consult@tion*", a Computer-Supported Collaborative Learning (CSCL) environment for remote CRL sessions [4]. It is composed of a set of cooperative platform-independent tools, developed in JAVA™ language. These tools allow the CRL group to communicate and to share information during the remote sessions.

Multimedia data exchange is especially useful in cardiology where clinical reasoning is mainly based on graphic resources obtained from imaging machines, such as thoracic radiography, electrocardiography, vectorcardiography, magnetocardiography, cardiac magnetic resonance imaging, cardiac computed tomography, phonocardiography, echocardiography, etc... [5] [6]. In *Virtu@l Consult@tion*, the multimedia resources are close to formats that students will find in their professional lives.

2. Pedagogical gaps

CRL is a pedagogical method which is used during the last years of the medical education cursus. At the same time, students do their training periods in the hospitals. Sometimes it is difficult for them to attend face-to-face CRL sessions.

During the CRL sessions, students simulate a medical consultation. One student plays the role of the patient. He answers the questions from students who interpret the role of physicians. The "patient" consults the information about the real patient from a paper clinical case. But it is sometimes difficult to interpret the symptoms, especially cardiac and pulmonary dysfunctions.

Most of the time, students do not use the information in the real formats. Currently, they use a verbal description of

exams, even for medical imaging. In cardiology, it is important to prepare students for analyzing and interpreting information from digital data because digital information is currently used in professional situations.

For reducing these gaps between learning and practice, we propose integrating the use of computers during CRL sessions in order to:
1. represent the symptoms of an illness thanks to multimedia data,
2. allow students to interpret raw data, instead of using summarized information,
3. access remote on-line CRL sessions from anywhere,
4. initialize students to tele-medicine technologies like tele-consultation, collaborative diagnosis and tele-transmission of complementary exams.

3. Methods

In order to satisfy our goals, we proceeded as following:
1. the interactions within the group that participates in CRL sessions were analyzed and classified,
2. the software characteristics supporting each kind of interaction were identified,
3. different pieces of software were included in a learning environment.

3.1. Interactions during CRL sessions

During classical CRL sessions, each member of the group (6 to 8 people) plays the role of the one of the three interveners of a medical consultation (patient, physician, secretary), and the group is coordinated by a tutor. They use some information sources, like clinical cases (in paper format), the secretary's annotations on the blackboard or medical imaging. If we consider the people of the group and the information sources as "participants", we can classify them into two categories, according to the possibility of interaction: *active* (people) and *passive* (information sources) participants. Active participants can communicate with all participants, whereas passive participants can exchange information only with an active participant.

After analysis of the communications, these can be regrouped into four categories. Broadcast and private communications involve only active member interactions, and controlled and free communications are the interactions between active and passive members.

Broadcast communication. In this kind of communication, an active member sends a message to all active members ($1 \rightarrow N$).

Private communication. This form of communication can be established between two active members ($1 \rightarrow 1$).

Controlled communication. An active member must be authorized to communicate with a passive member (information source).

Free communication. This communication type, established with a passive member (information source) does not require authorization.

3.2. Software characteristics

In order to support a remote communication group, we selected the characteristics of software that can support the four kinds of communications previously described.

For *broadcast* and *private* communication, according to users' needs, asynchronous or synchronous communication software can be used. In the case of synchronous communication, it is important to keep the same characteristics as in a face-to-face communication; for example, only one person speaks at the same time. If this rule is not respect, the communication can be incoherent or more complicated to follow. Sometimes, some rules can be explicitly established for designating the participation order. It may be useful to indicate to the group some piece of information that is implicitly transmitted in face-to-face session; for instance, each person knows who is present at the meeting, who left the session, who is speaking, who is writing, etc. Awareness tools can be employed for transmitting this information.

For *controlled* communication, it is necessary to determine who can read or modify the sources of information. The privileges are determined and controlled by the role of the person participating in the simulation. *Controlled* and *free* communication use pieces of software that depend on the information format (text, image, sound, video, etc.). Cooperative tools may allow the group to share information, for example the information on the blackboard. In Table 1 we show some examples of pieces of software for each kind of communication.

Communication form	**Software example**	
	Asynchronous	**Synchronous**
Broadcast	Email	Chat
		Instant Messaging
Private	Forums	Audio conference
		Video conference
		Awareness tools
Controlled	Private document access Authorization control	
Controlled Free	Format dependent software: - Text editor - Multimedia player - Cooperative tools	

Table 1. Software examples for each communication type

In our case, we selected textual synchronous communication, images and sound players and cooperative whiteboard tools for our learning environment. The characteristics of *Virtu@l Consult@tion* are described in next section.

4. Learning environment

Virtu@l Consult@tion is a learning environment which has been created for supporting remote CRL sessions. This environment was developed in Java™ language, it can be used from different operating systems. It is composed of several pieces of software and groupware.

It has a communication server which allows the group to question the patient and to discuss after the session. The multimedia information is stored in a web server and it can be indexed in a database. Only the patient and the tutor can access them using a resources index. Cooperative tools allow information to be shared by the whole group and support tools are used for displaying resources. These tools were created for supporting all activities carried out during an on-line CRL session. *Virtu@l Consult@tion* has at the same time, a shared graphic interface for group interactions and also a private zone.

Communication. Communication is mediated by computer: we chose textual communication because it is easier to interact with different operating systems and it is not necessary to have a high speed Internet connection[1], see Figure 1. The communications are serialized, that means that we display doctor's question and patient's answer before showing the questions of other doctors. This makes the reading easier. Information about participants is also shared with the group.

Shared information. Students' notes and the secretary's summary are available for consultation during the simulation, see Figure 2. Tutors can correct them and send feedback to students individually using a private communication. Comments and marks made on medical imaging are also available for consultation using a graphic whiteboard.

Multimedia sources. Textual information about the medical data from patients was replaced with multimedia data. Thanks to multimedia data (image and sound), students can analyze and interpret raw medical data like in a real situation, see Figure 3.

5. Evaluation results

Thirty seven people participated in this experiment. Only 29 questionnaires were completed (78 %). The main purpose of the evaluation was to verify the feasibility of creating CRL sessions at distance and to validate that the learning environment was adapted to this kind of learning, which means that we validate our analysis of communication during a CRL session. Ergonomic aspects of *Virtu@l Consult@tion* and the importance of multimedia resources were also evaluated.

[1]During the evaluation, we remarked that several participants did not have a high speed internet connection or did not have yet a personal computer.

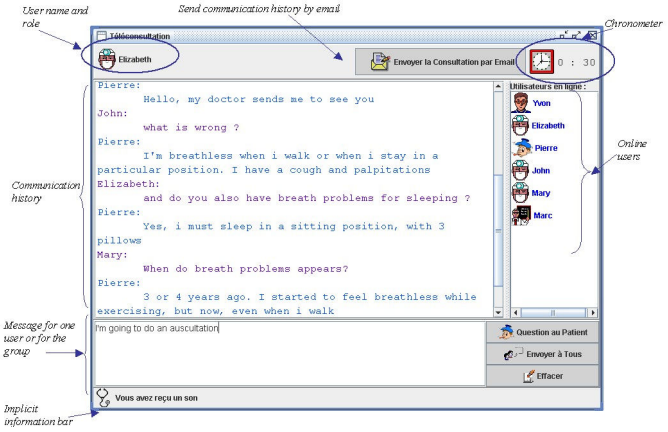

Figure 1. Textual communication

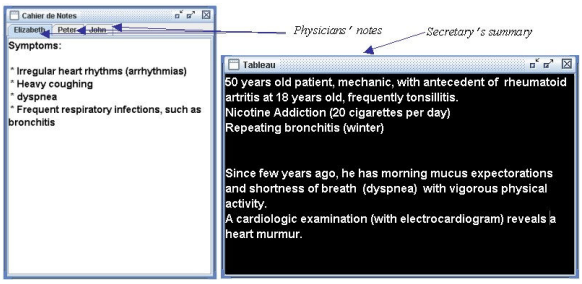

Figure 2. Electronic notebook and blackboard

Students and tutors participated voluntarily in one of three different groups. The two first groups were formed by students training in general practice. They were in a real situation: attending centralized sessions was difficult for them and they used *Virtu@l Consult@tion* at distance (at home). The third group had no problem in attending centralized sessions since they were taking other courses at the faculty (unspecialized as yet): these students participated in pairs in a computer room at the university.

CRL sessions were created for small groups: even if computers tools allow information to be diffused to huge groups, the learning activity is not efficient. For this reason, we obtained the best results in the two first groups.

The results of this evaluation are presented in Table 2

6. Discussion and conclusions

Computer tools have been used for implementing these communications at distance. They are integrated in a learning environment. We have tested *Virtu@l Consult@tion* in a real situation and users considered it adapted for CRL sessions. This evaluation has permitted us to validate our classification of communications.

Virtu@l Consult@tion uses classical technologies and does not require special hardware or software. The textual communication was appreciated by students, because

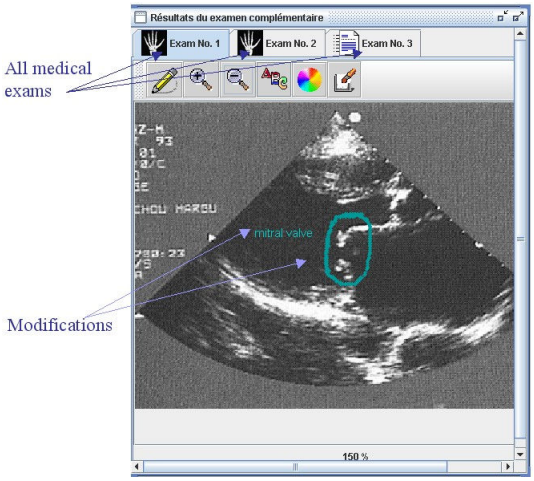

Figure 3. Cooperative graphic whiteboard

Participants	7	6	16
Easy coordination (for tutor)	Yes	Yes	No
Remote session	Yes	Yes	No
Feasibility (in %)			
Remote sessions	100	100	54
Adapted to CLR	100	100	56
Ergonomics (in %)			
Utility	86	100	75
Easy to use	100	100	62
User-friendly interface	72	83	69
User satisfaction (in %)	86	100	62
Multimedia support utility (in %)	100	100	94

Table 2. Evaluation results of *Virtu@l Consult@tion*

they participated in a much more spontaneous way than in face-to-face sessions. Students can also recover lost communication after an Internet crash or momentary absence. Session logs could be used after sessions by tutors for improving learning. Nevertheless, this form of communication is not natural.

Virtu@l Consult@tion can be used in all medical disciplines, but it is especially useful for cardiology learning, because, in professional practice, cardiologists frequently use digital medical information: thoracic radiography, cardiac magnetic resonance imaging, cardiac computed tomography, dynamic electrocardiograms and echocardiograms, phonocardiograms, etc. Raw medical data interpretation was regarded as helpful during our experiment and could be included even in face-to-face sessions. However, this activity would increase the length of the session. At present only images (2D, 3D, animated) and body sounds are used. Palpation (touch sense) was not implemented because it requires sophisticated hardware, like haptic interfaces [7][8].

To have efficient CRL sessions, the communications must be serialized and the group size must remain small. Medical data employed in CRL sessions must be continuously updated and presented in formats that are used in the professional context.

In the future, other technologies could be used in *Virtu@l Consult@tion* such as video conference communication to include implicit communications, virtual reality and augmented reality to make a virtual patient more realistic.

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