

Remote medical education via Internet enhanced services – the REMEDIES platform for distant training

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Abstract—Continuing medical education is considered as a very important aspect in the development of skills of practicing physicians and the introduction of new concepts and developments in health care provision. Studies have shown that conventional CME techniques including self-studying and lecture attending have limited impact on clinical practices. The world wide web provides a very efficient and cost-effective delivery system for conveying anywhere and anytime multimedia information to large user groups. Although there are a number of CME web sites available today, the majority of them are static and text-based thus not offering interactive functionality and multiple content. To exploit modern telematics technologies and within the framework of the Leonardo da Vinci programme, the REMEDIES project developed an interactive web-based distance-training infrastructure. The REMEDIES system incorporates two training modules – a web-based training platform and a teleconference training platform. The system has been validated in terms of technical performance and user functionality in a controlled target group comprising of young medical doctors and medical students in the specific areas of radiology and laparoscopic surgery. The results of the trial have demonstrated the compliance of the system to the defined functional requirements and the potential usefulness to the defined training goals. Trial results have also demonstrated the need of extension of the educational material within the platform especially for the purposes of continuous education.

Keywords— *e-learning in health, continuing medical education.*

1. Introduction

The professional development of practicing physicians is a lifelong procedure that is based upon opportunities to expand theoretical knowledge and apply newer methodologies and techniques to patient care. Continuing medical education (CME) is one of the elements in this lifelong procedure and has a long history in supporting physicians expand their knowledge. Traditional CME programs include attendance of conference and lectures, participation in training workshops and self-studying. However, these types of conventional CME activities have shown limited impact on clinical practices and healthcare outcomes [1, 2]. On the other side, activities that simulate actual work conditions or implement interaction between trainers and trainees along with actual case data have proved to improve results [3, 4]. In the past years, the developments of telecommunication and informatics technologies have demonstrated their feasibility in

supporting and enhancing CME programmes [5–7]. Furthermore, the world wide web has led to the rapid growth of medical information and continuing medical education services. In January 2004, there were more than 270 CME sites with more than 21 000 hours of CME credits offered online [8]. However, a large number of these sites (30%) contain only textual information, 15% contain slides with video, and only 3% are guideline based [8]. In that sense it is clear that in most cases the benefits of web-based CME, especially the benefits arising from the use of computers, are not fully exploited.

To address the issues related to the use of modern telematics technologies applied to medical distance learning, we have introduced the REMEDIES project implemented under the Leonardo da Vinci EU programme (http://europa.eu.int/comm/education/index_en.html). The aim of the REMEDIES project was to design and validate a web-based technical platform for distance training applications within the medical community. Modern Internet technologies and current trends in computer-based training were the basic technical requirements for the system design.

2. System design and integration issues

In the initial project phases a thorough user requirement analysis has been performed to define end-users requirements. To aid the requirement analysis, a structured questionnaire has been designed and distributed to the target group along with interviews to selected key-users. The analysis during the requirements phase revealed the necessity of an easy-to-use interface, in order to comply with the needs of users that may not be familiar with computer. Other conclusions from the requirement analysis included:

- reducing health and safety risks;
- easy, comprehensive user interface for the e-learning platform;
- ability to use the system in each individual's workplace;
- tools for evaluation and supervision of students;
- high quality video capabilities especially for the online surgery scenario.

Based on the results of the requirement analysis the specifications of the system were subsequently defined and the system architecture was defined. The REMEDIES system design requirements incorporate two main training modules: a web-based platform and a interactive tele-conference platform.

In the following sections the components of the REMEDIES platform are presented in details.

2.1. A web-based training platform design

The web-based e-learning environment was built using the Lotus Learning Space 5 (LLS5) [9] software as the core-developing environment. Figure 1 depicts a schematic overview of the e-learning platform.

The LLS5 is the core e-learning platform. LLS5 consists of two major interfaces, the administration interface and the student interface. LLS5 utilizes a Microsoft SQL server (MSSQL) database in order to keep all the essential information for the courses and the Internet information services (IIS) platform to publish the LLS5 interfaces to the Internet. LLS5 handles any available web-based material like for example HTML pages, multimedia content, etc. It has a built-in course constructor where every detail about a course can be adjusted to the teachers needs. To serve platform consistency and contingency, courses physical data are kept separately to the hard disk under the IIS publish directory.

The IIS is a Microsoft Windows service that broadcasts the LLS5 interface to the Internet and can be customized to meet every technical and security requirement. IIS retrieves the lesson outline from the MSSQL via ODBC (FILEDSN) and publishes the corresponding web pages from the hard disk. Additionally, to enable video web streaming, Microsoft Windows media services were employed and the appropriate parameters were configured.

The MSSQL server is the database used by LLS5. It contains every lesson detail including courses descriptions, metadata for the courses and user information and of course link to the “virtual path” of the IIS, which in turn links to the material (web pages, video, sound, etc.) located at the hard disk. The LLS5 is capable of monitoring every lesson activity, such as students’ participation, grades received during examinations, etc. Furthermore, the MSSQL server interface provides with backup capabilities to archive all handled information.

The hard disk is the physical part of platform. It contains every web page, designed as lesson, announcement, etc. It is being used by IIS to access training material. It contains the HTML pages, courses, multimedia content and video with metadata files. The material has to be sent to the hard disk before the creation of a lesson and the organization of the hard disk data is responsibility of the system’s administrator.

The administrator interface provides an intuitive web based platform to create and manage courses and access student information. In order for a course to be completed,

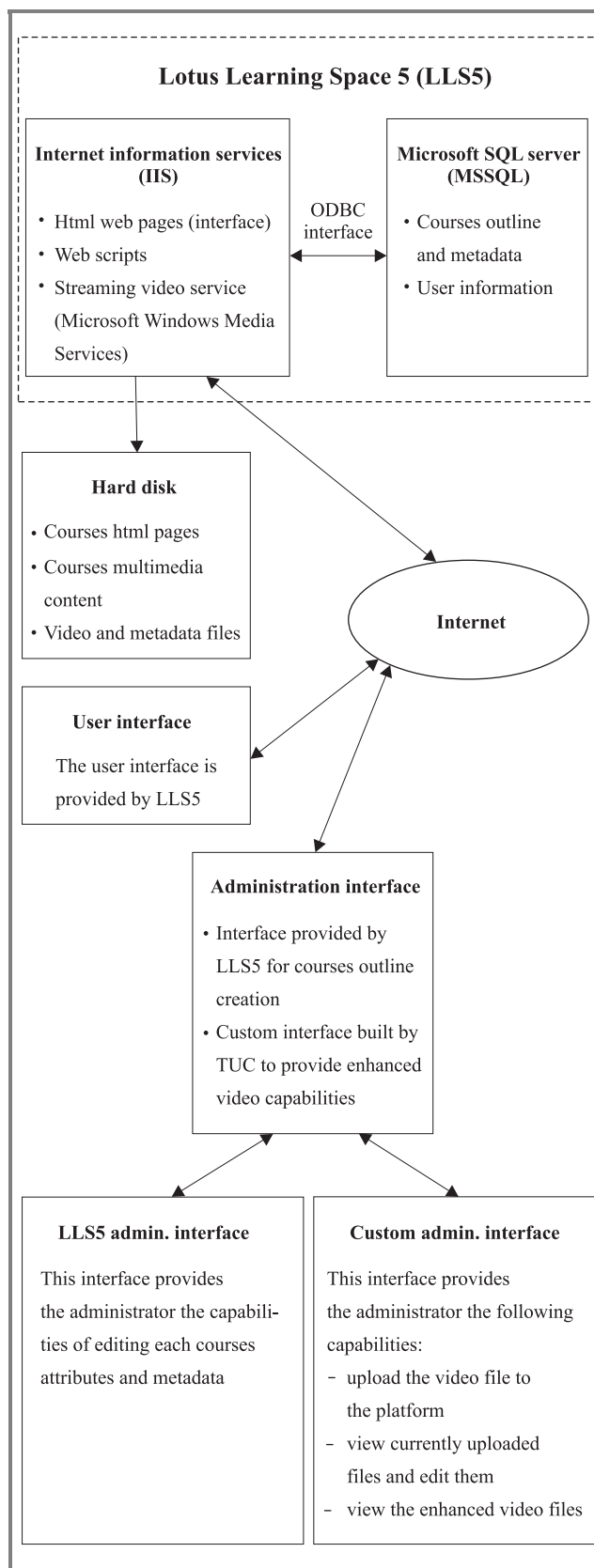


Fig. 1. E-learning platform system architecture.

the physical creation of the lesson to the hard disk is required and the correct set of all necessary parameters (such as “virtual paths”) should be established.

The custom administration interface provides the platform with video editing and playing capabilities. It consists of three main parts: the enhanced-video program player, the enhanced-video program editor and the web-based enhanced-video interface.

The user interface is a web-based interface that handles all user activities. This interface can access all course material available from the server. In order to access lesson information the user must be an enrolled user. All user activities are being kept to MSSQL and are available to the trainer.

Finally, the Internet is the medium by which all these can be made available to the public and implements the virtual classroom.

2.2. Interactive teleconference platform – components and configuration

The second main component of the REMEDIES training system is the interactive teleconference training platform. This system utilizes Microsoft media encoder and Microsoft media services software for capturing, encoding and broadcasting video signals. In order for the audience under training to receive a better conception of the procedure being presented, both the medical video sequences (e.g., laparoscope video signal) and the operating room video image (showing the participants in the operation) are being captured with the use of appropriate grabbers. After capturing and encoding, both videos are transmitted to a multicast streaming video server responsible for broadcasting. End users are able to connect through local area network (LAN)

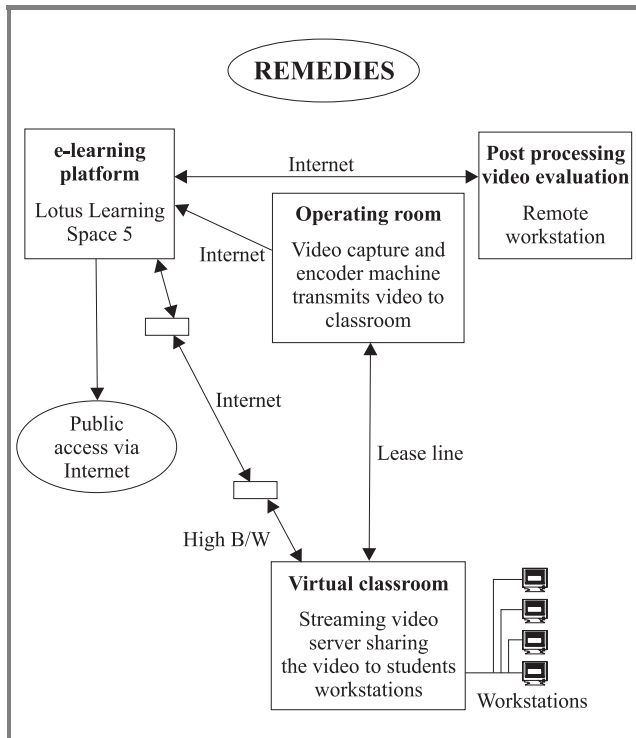


Fig. 2. Teleconference platform design.

at given URL using media player software and watch an endoscopic operation in real time. Additionally all videos are stored in order to be also accessible at a later time on the REMEDIES e-learning platform.

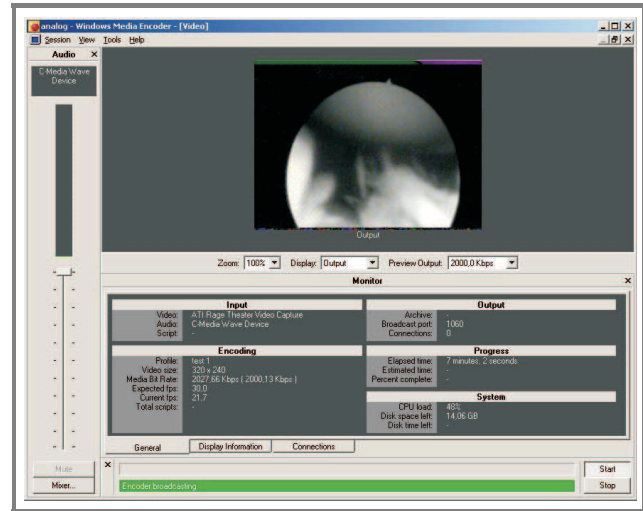


Fig. 3. Video captured from the endoscope and broadcasted.



Fig. 4. The end user's view of the video signal.

Figure 2 depicts the design of the videoconference platform including the operating room and the virtual classroom. Figure 3 presents real-time encoding and broadcasting of the endoscope's video signal whereas Fig. 4 illustrates the end-user's view.

3. Pilot set-up and demonstration

The pilot demonstration of the REMEDIES training system was performed at the premises of National Technical University of Athens (NTUA), demonstrating the e-learning platform functionality and a real-time transmission of an endoscopic operation performed at ARETEION hospital in Athens through the interactive teleconference platform.

The whole system functionality was demonstrated during the pilot in order to test and evaluate the application under real operating conditions. The system was presented to an audience of both technical and medical oriented staff, and the evaluation was made mainly through questionnaires completed by them at the end of the procedure. A second evaluation procedure was performed over the Internet, involving users of the e-learning training platform that were also supplied with the videos captured during the real-time teleconference.

3.1. Web-based training platform

Following the design and development of the REMEDIES platform, a controlled system validation and demonstration phase has been performed. The web-based training platform has been established and hosted at the following URL: <http://morfeas.systems.tuc.gr>. In terms of content and for the purposes of the pilot demonstration phase, the application was populated with the following training courses:

- **HDR brachytherapy as a monotherapy for prostate cancer.** The course provides an overview of essential information on prostate cancer pathology and a number of relative links in which the trainee can search for more information. A presentation describing an HDR brachytherapy treatment is also provided, consisting of diagnostic images and implementation procedures.
- **Traumatic dislocation of the patella and osteochondral fractures of the knee.** The course provides basic information related to the traumatic dislocation of the patella accompanied by diagnostic images and 3 videos presenting the procedure of arthroscopic removal of the osteochondral fractures of the knee.
- **Endoscopy of the pancreaticobiliary tree.** The course provides the basics of endoscopic retrograde cholangiopancreatography (ERCP), a video presenting an ERCP operation and a video presenting a laparoscopic cholecystectomy operation.

Online courses can be easily updated with more information (images, videos) or modified by the trainer providing the course material. The need for platform updating and enrichment with new content (especially videos) was successfully addressed by the development of the REMEDIES administration interface. This software, accompanied by the corresponding administration interface manual, provides the trainer with the capability to easily upload new videos and respective explanatory information on the platform. Apart from this, the available courses can be easily managed and maintained through the dedicated user friendly and easy to use software.

3.2. Interactive teleconference platform

Initially the teleconference platform was successfully tested on a local area network environment with a pre-recorded video from an endoscope. The test has revealed the system potentials and minor modifications dealing with system operation were implemented. After the successful implementation and operation of the videoconferencing platform on a LAN environment, successive tests were performed at the ARETEION hospital, using real time video from the endoscope and the digital camera to record images during the operation. A computer was installed in the operating room and connected to both the digital camera and the endoscope/laparoscope's output. The digital camera was placed on a tripod near the operating table, ensuring stability and specific angle of view. This camera recorded and transmitted real time video and audio from the operating room environment. The endoscope's video signal was also simultaneously transmitted. All video and audio signals were encoded and broadcasted by the computer. Videos captured were also saved on hard disk in order to be accessed at a later time.

The operating room and the hospital's network infrastructure were thoroughly analyzed during the initial trial phases. The operating room could provide a fiber optic and an UDP connection but due to the limited financial resources available by the project, UDP connection has been used. In parallel to network connection testing, successive tests were performed in the operating room to define the optimum configuration parameters. Tests resulted in a reliable video grabbing encoding and broadcasting procedure of the laparoscope signal and the digital camera signal. Both videos were successfully broadcasted from the PC in the operating room and accessed via Internet by registered users with the use of media player. The main difficulty encountered in the testing phase was that access procedures to the operating rooms were very complicated and slow because the operations' daily program was not known until the night before the operation. Furthermore, hygiene rules that should be ritually followed imposed some additional problems.

For the pilot demonstration, a gastrointestinal endoscopy procedure was selected. A gastrointestinal endoscopy is the visual examination of esophagus, stomach and first part of the intestine using a fiber optic instrument. In some cases tissue may be taken for further tests. The REMEDIES videoconference platform was placed in the endoscopy room of ARETEION and configured to capture the video signal of the endoscope and the video of the camera recording the room environment and the actions of the doctor performing the endoscopic procedure.

The endoscopic procedure (gastroscopy) demonstrated was covered by the two video signals, one coming from the digital camera mounted on the tripod and capturing the operating room environment and the procedures and actions of the doctor and the second was the signal from the endoscope itself, showing the same view as the one appearing on the doctor's monitor. The doctor was also describing

the procedures he was performing and what the endoscope was showing, providing attendees with audio information as well.

After the end of the endoscopic operation, the attendees were requested to access the REMEDIES web-based e-learning platform and the courses included in that. Besides familiarizing themselves with the navigation tools and options they downloaded images and videos relevant to cases studied. At the end of the training session, each attendee was required to complete the evaluation questionnaire.

In order to collect feedback from more people, both videos transmitted during the live videoconference were encoded and stored in order to be sent at a later time through Internet. In this way, the exact videoconference procedure (apart from the real-time parameter) was presented to a wider public to evaluate it together with the web-based platform and provide us with feedback. Evaluation feedback was mainly collected through the questionnaire that was delivered to the attendees during the pilot and via e-mail afterwards. The questionnaire was also available in the e-learning platform itself, to collect feedback from web-users as well.

4. Pilot evaluation results

Evaluation feedback was mainly collected through the questionnaires that were completed by the attendees during the pilot phase. The questionnaire was also available in the e-learning platform itself, to collect feedback from web-users as well. The questionnaire comprised of two parts, the first including questions to evaluate the REMEDIES training system in terms of functionality and the second in terms of medical content. During the pilot demonstration 36 questionnaires were collected from the attendants. Another 80 questionnaires have been completed during the second evaluation procedure that took place over the web. A total of 116 questionnaires were gathered, which is considered an adequate number to ensure evaluation results statistics. Table 1 consolidates the results of the pilot study.

The analysis of the above-presented results demonstrates that the majority of participants have evaluated very positively the technical and usability characteristics of the system. In particular both the user interface and the navigation and content handling issues were given positive responses by more than 97% of the participants. This is very important given the fact that a significant percent of users (29%) were not familiar to computer based training tools and had small or no computer use experience. These results have been extremely important since the main aspect of our work has been focusing on the system functionality and the technical constraints imposed.

Regarding the medical content evaluation, results were not as high as in the previous section. Actually 58% of users

evaluated medical content as being average or below average whereas 42% considered as good or above. The reason for this is that users were of different academic level some of them being trained physicians and some being students. Therefore their educational needs differ significantly and these evaluations were also different.

Table 1
Results of the pilot evaluation phase

General questions	
Trainee sex distribution	71% male 29% female
Use of computers	42% once a day 58% once a week
Familiarity to electronic training tools	42% very familiar 29% somewhat familiar 29% not familiar
Access to web	41% work 33% home 26% school
Usability features	
User interface	29% excellent 68% very good 1% good 1% average 1% poor
Ease in navigation and content handling	4% excellent 89% very good 4% good 3% poor
Medical content	
Content quality	19% excellent 23% good 30% average 28% poor

Although the main efforts of the project were along the technical development issues, the results of the evaluation with respect to the content indicate the importance of the material implemented within the platform. It is conceivable however, that in order for the system to be used routinely, the content should be significantly advanced both quantitatively and qualitatively in order to serve the needs of life-long training of medical professionals in their everyday clinical practice. For this, we are currently in collaboration with medical scientific bodies and organizations to collect and populate the system with extensive educational material appropriately selected for the needs of users currently being medical students and trained physicians undergoing CME.

5. Conclusions

Within the framework of the REMEDIES project we have designed and developed an interactive web-based distance-training infrastructure. The REMEDIES system incorporates two training modules: a web-based training platform and an interactive teleconference distance-training platform. The system has been validated in terms of technical performance and user functionality in a controlled target group comprising of young medical doctors and medical students in the specific areas of radiology and laparoscopic surgery. The results of the trial have demonstrated the compliance of the system to the defined functional requirements and the potential usefulness to the defined training goals. Trial results have also demonstrated the need of extension of the educational material within the platform especially for the purposes of continuous education.

In conclusion, while preliminary user testing has shown highly positive results, a formal evaluation study is necessary to determine the educational validity of the proposed technologies. For this the preparation of a large database of educational material is required. This is a planned activity that will be performed in collaboration with the Athens University Medical School as well as other medical scientific bodies. Next phase of the project is to design and implement a controlled evaluation of the CME platform in specific medical cases where cost-effectiveness, clinical practice transformations and healthcare outcomes will be assessed.

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