# E-tools for Education and Research in Chemical Engineering

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**Abstract:** New methods for e-learning and research are growing up in the field of chemical engineering, as computer aided tools become more important. Concepts as distributed laboratories for education and research, associated to the e-learning and lifelong learning tasks, have been implemented in specific applications at the Faculty of Chemistry and Chemical Engineering of "Babes-Bolyai" University. Application results such as the remote laboratory, the distributed computer aided control laboratory and the Web based tools for e-learning are presented. Incentives, and challenges of the developed applications are shown and perspectives for the future are foreseen.

**Keywords:** e-learning, remote laboratory, Web tools.

## 1. Introduction

Developments of Information Technology (IT) and computer sciences imply rapid changes in the way teaching and learning concepts are implemented, as they have to keep pace with the remarkable progress in these fields. In the last years a set of new education systems has emerged, such as: computer aided e-learning, long-distance learning, teaching systems for life-long learning, interactive teaching systems and electronic courses, all using the computer as the main target-oriented tool.

The *European knowledge based society* has become one of the main targets for the European Community, as former president of the European Commission stated: „*eEurope is a roadmap to modernize our economy. At the same time, though its eLearning component, it offers everyone, but particularly young people, the skills and the tools they need to succeed in the new knowledge based economy*".

The striking developments of IT have caused, in almost every field, the penetration of new methods and techniques both for teaching and for learning but also for performing the research work. New methods in Computer Aided Process Engineering (CAPE) education have to make extensive use of integrated data acquisition and analysis, intelligent tutorials, interactive audio/video and virtual instrumentation. Sharing education using Internet is still a growing process as e-learning covers many aspects ranging from e-library access to remote location laboratories [1].

Two of the main directions for the development of the new learning and teaching techniques are the setting up of the distributed laboratories and the enlargement of long distance learning as important tools for performing long life education. The gap between the course and the laboratory may be filled up with courses having included laboratory demonstrations and laboratories may be set up to introduce, in a practical oriented way, the concepts of the courses. Soon, and in continuous growing coverage, the new learning methods will replace the classical education methods.

Challenges of the labour market for the chemical engineers ask, in a continuous larger extent, the development of competences and skills allowing the rapid integration of the graduate student into the specificity of the job's tasks. The multidisciplinary characteristic of the education is becoming, for the employers, one of the most appreciated attributes. These needs may be fulfilled by a larger diversity of practical applications and laboratory experiments. But extending the quantity and quality of laboratory applications may become cumbersome due to the implied costs. As a result, the access to laboratory experimenting facilities using Internet may be a good choice for these new challenges.

But the education is not the only one that may benefit by the potential of broadening the experimenting tools. The research activity is another good candidate for obtaining substantial incentives by the possibility of accessing and using methods and equipment via Internet. Nowadays, the education and the research networks have to become more interlinked, as polarisation of competence of the research groups in particular fields has become a reality and the need of working together in complex projects is an important demand of the market.

These are some but not the only reasons for finding new methods and means for performing education and research in the new framework offered by the Internet and the CAPE tools.

## 2. Experimental

Modern education processes are also assumed for chemical engineering education in the instruction process of chemical engineers at "Babes-Bolyai" University of Cluj-Napoca, Faculty of Chemistry and Chemical Engineering. Computers play different roles in chemical engineering education, such as: simulation, data acquisition and monitoring, computer aided testing, visualization, virtual reality. Using special software applications and adequate hardware, the correlation between theoretic concepts and practical examples become possible, having substantial hardware and software support.

The *chemical engineering* curricula includes several courses aimed both to form the basic skills for using the computers, computer driving licence, (MS Office, Matlab, C-language) and the thoroughgoing study of different software tools (Simulink together with specialized Toolboxes, LabView, FemLab, ChemCad, Aspen). One of the five directions of study in Chemical Engineering is Computer Aided Chemical Engineering (CACE) specialization. Students of this CACE specialization perform special courses (with associated laboratory works) devoted to support extensive use of computers, such as: Chemical Process Modelling and Simulation, Theory of Systems (basic and advanced concepts), Numerical Methods, Hardware and Software Process Interface, Artificial Intelligence, Process Control, Optimisation and Integrated Process Design.

The master studies for Advanced Process Engineering uses laboratory techniques assisted by computers and have special courses for: Optimal Process Design, Advanced Process Control, Integrated Process Design based on advanced software for modelling, monitoring and control.

The PhD programs are developed to extensively use the computers for all stages of the students build up and research work: documentation, modelling and simulation, data acquisition and control of laboratory equipment, data processing, chemical process control, process design and optimisation.

The starting point of the presented work has been the consideration that "learning by practical experimenting" is a fundamental part of the engineering education. Designing and building state-of-the-art experiments is time-consuming and requires funds and effort. Sharing experiments locally and remotely allows unique laboratory equipment to be used more efficient, brings down the cost per student, and makes more experiments available to students [2].

First, applications have been developed to introduce the telelaboratory paradigm in different chemical engineering courses, using LabVIEW (National Instruments) and Visual Basic software. The applications allow the users to access the distillation column pilot and other pilot plants in order to execute experiments locally or remotely.

Second, a computer aided process control laboratory has been built. The laboratory equipment consists of different pilot plants where processes such as: liquid accumulation in a tank, heat transfer in a jacketed reactor, gas accumulation in a set of reservoirs or flow of liquid through a pipe-network may be investigated by experiment. Each of the pilots is fitted with specific measuring, actuating and control instrumentation. The µP-based REX F-400 local controllers, connected by serial RS485-RS232 converter to a PC, represent the regulatory control level. The PC represents the upper control and monitoring level of the two-level distributed control hierarchy.

Third, Web based software tools have been designed and executed by integrating MATLAB Web Server, PHP, MySQL and LabVIEW Web Server

## 3. Results and discussion

The telelaboratory application is coupled with several remote experiments, which are used in the Process Control, Mathematical Modelling of Chemical Processes, and Advanced Control of Chemical Systems courses. Students prefer projects related to the remote experiments since this decreases significantly the problems related to the scheduling of working groups. Experiments can be performed even from their residence. This remote experimenting module has been developed in the Server/Client architecture using the advanced features of Labview, which provides fast means for developing the required network security procedures and the user-friendly interface [3].

The functions of the telelaboratory applications are:
- Supplying experimental data by offering access for other applications from anywhere the world using the Internet (remote data acquisition);
- Providing an introductory DAQ course illustrated with bitmap graphics and simulations;
- Receiving and displaying in real time the data obtained from the data provider by a user-friendly graphical interface;
- Establishing remote sound and image transfer between the data provider (server) and receivers (clients) by the use of a video conference software.

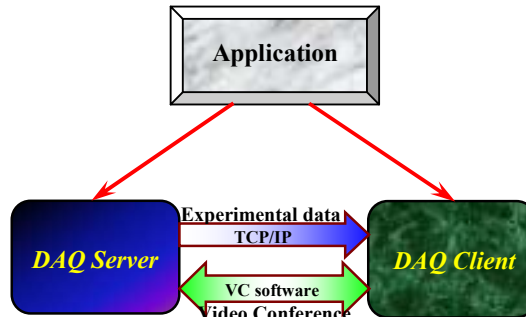The main structure of the telelaboratory applications is presented in figure 1.



Fig.1. Main structure of the telelaboratory applications.

Remote video and sound transfer is performed using microphone and Internet QuickCam. The CUSeeMe videoconference software is integrated into the application. The software creates the feeling of being present at the information source.

The DAQ Server application runs on the computer that is the data provider. Its functions are: acquisition of data on the selected channels (performed by the Data Acquisition DAQ kernel), transmission of data using Internet (performed by the Communication kernel) and transmission of audio/video information (performed by the Video Conference Software). A typical DAQ Server window is presented in figure 2.
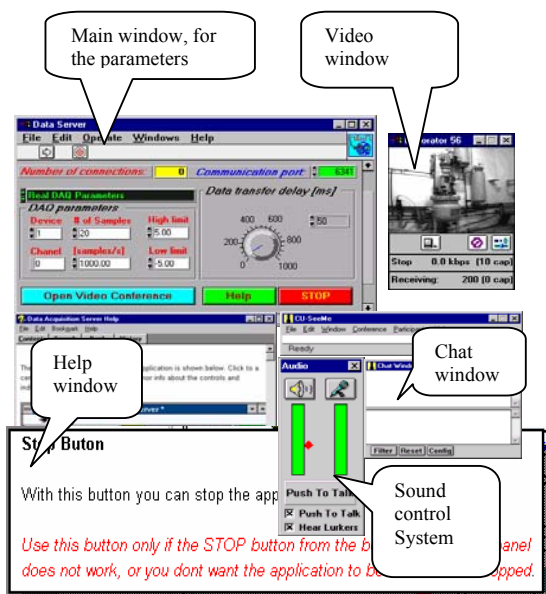
Fig.2. The DAQ Server application window.

The DAQ Client application provides:

- an introductory DAQ Course consisting in simulations, exercises, accessories (videoconference, videodocuments, glossary etc), complex Help system, presented in figure 3;
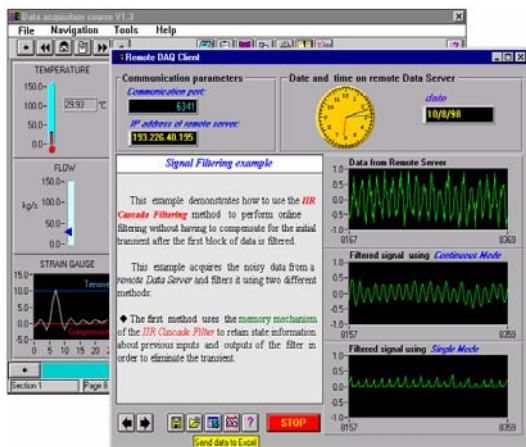


Fig.3. Remote DAQ Client window with the DAQ course and glossary.

- acquisition of real-time data from different pilot plants, via the DAQ Server application, presented in figure 4;
- remote control for process variables of the different pilot plants, presented in figure 5.

The remote control window presented in figure 5 shows the pressure control in a series of three-vessel of a pilot plant. Control is performed by the Remote DAQ Client application. The application window allows the setting of

the parameters for the Internet address of the Server, the location of the saved files and controller tuning parameters.



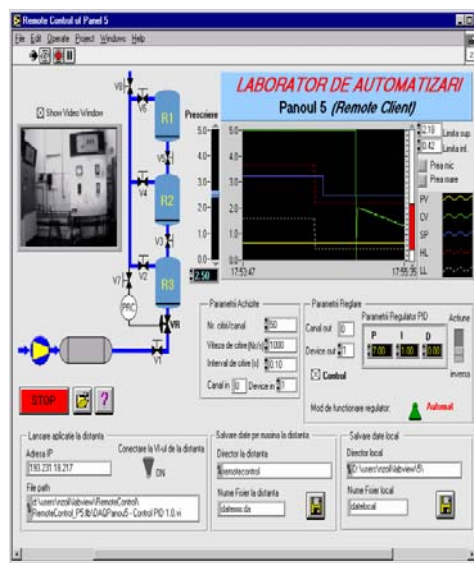Fig.4. Remote DAQ Client window with remote data acquisition.



Fig.5. Main window for the Remote pressure control application of the DAQ Client application.

The Computer Aided Process Control Laboratory application is presented in figure 6. It performs several tasks. The basic task allows the bi-directional communication between the local controllers and the PC by specific protocol. The monitoring task offers the rapid overview of the different control loops being also provided with override alarm functions. Detailed information on a particular pilot plant dynamic behaviour and its controller may be obtained by means of another task. Historical information, previously saved in special files, can be used for on line or off line data interpretation and processing.
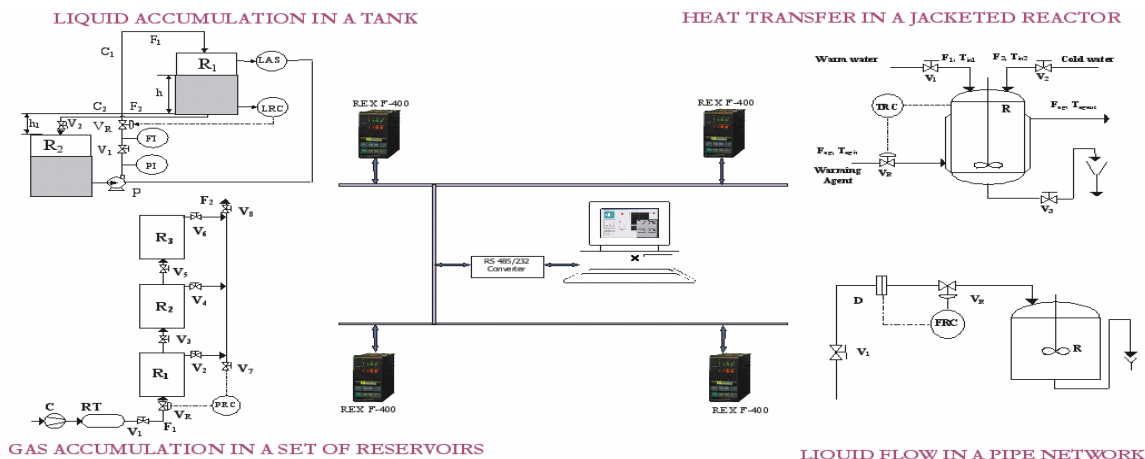
Fig.6. The Computer Aided Process Control Laboratory pilot plants network.

The flexibility of the application makes possible the practical demonstration of different steps of the chemical process control curriculum such as: mathematical modelling coupled with process identification; frequency response, stability, dynamic behaviour of transducers and actuating elements; P, PI, PD, PID controller response and tuning, implementation of a multivariable control strategy (Model Predictive Control) in a supervisory approach.

One of the main advantages of the following learning/teaching tools is that it can be easily accessed without any software (using only a web browser, usually implemented in the operating system). In order to obtain this advantage server-side scripting languages are used. The following example shows the main page of a web site that interactively computes the concentration variation of chemical compounds in a system with 2 successive chemical reactions. This site was developed using PHP and MATLAB - Web Server component – together with the software tools MySQL and LabVIEW, figure 7.
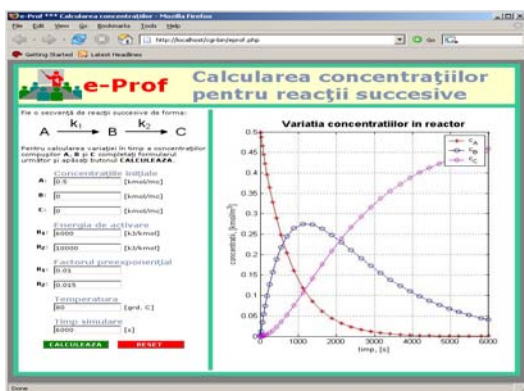


Fig.7. The interactive Web application.

## 4. Conclusions

Teaching and learning methods change rapidly in the attempt to capture the spectacular progress of information technology and computer sciences. Research tools and working methods undergo a similar process. Applications developed at the Chemical Engineering Department of "Babes-Bolyai" University follow this process. The main incentives of the new developed applications are:

- allowing access to real and representative experiments for engineering education and research;
- reducing costs access to expensive experimentation facilities;creating a new framework for long distance learning and experimenting;
- revealing efficient tools for life-long learning;
- opening new opportunities for distributed work at research projects;
- demonstrating potential developments for a large variety of applications.

Further developments are expected in the future as communication channels become more reliable and transfer rate is increasing.

## 5. References

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## 6. Acknowledgment