

## Development of an e-Learning System for Chemical Engineering Education

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**KEYWORDS:** *Chemical engineering education, e-learning, integrated system, curriculum development, education management*

**ABSTRACT:** *Today continuous efforts are devoted to fulfil locally the European and national policies in developing the higher education system, supported by information technology and communications (ITC).*

*This contribution presents a project aimed to develop an e-learning system for higher education. The project objective was the design of an e-learning pilot for a chemical engineering faculty of remarkable size and complexity, likely to undergo technological transfer through the diligences of the business partner. Administratively, the faculty consists of several departments, organizing the student professional specialization. Special requests for the communication system were imposed. Further more, in time, the system would evolve towards distance and continuous learning.*

*The former infrastructure was updated to support new network technologies (virtual networks). The starting point was an existing e-learning product (AEL) designed for the high school level. This was tailored to the needs and requirements of higher education in chemical engineering.*

*The main educational characteristic is complemented by the faculty organizational management. This refers to academic records, timetable for students and academic staff, students' examination and periodical assessment.*

*A large survey on the computer skills and attitude towards IT assisted education was conducted within the academic staff and student population. The strategy of developing specific chemical applications relayed on the survey conclusions. Consequently pilot topics were chosen to set up lectures, computing, and experimental applications using the virtual education system.*

### 1 INTRODUCTION

Today continuous efforts are devoted to fulfil locally the European and national policies in developing the higher education system, supported by information technology and communications (ITC). As regards Romania, development of infrastructure, communications and information systems and services represents the fundamental condition for general economic development, as well as for integration in the European Union.

Learning nowadays is a continuous and active process performed with a specified goal and applied to real life situations. In the past, the main criteria in selecting a higher education institution were connected with its prestige and location. In Romania, characterised by a relatively low life standard, the location criterion was an important one for potential students. On the other hand, the prestige criterion brought many foreign students to the Romanian Universities. The globalisation process tends to amplify both criteria. Thus, a true education market, governed by rules identical to any other services market, has been created. Because of this, many high prestige academic institutions, find themselves in a situation of loosing some of their students in favour of other institutions, located at larger distances, but better anchored in the education market.

Although University "POLITEHNICA" of Bucharest is the largest institution of engineering higher education in Romania, it feels threatened by this "distance shrinking" imposed by ITC in general, and by

Internet in particular. That's why the academic staff of the Faculty of Industrial Chemistry has envisaged some new methods in order to face the competition by applying new learning techniques and promoting in an efficient manner the services offered. This trend has given birth to a project of implementing an integrated e-learning system.

Developing such a system through ITC could be the main approach to avoid the so-called "digital divide": people with low computer literacy are likely to have lower accessibility to information on the web than those with higher computer literacy. This would cause a serious discrimination in the information society, as Internet is already a major source of knowledge and information in everyday life. Education must be responsible for avoiding this difficulty by seriously promoting computer literacy.

The industrial chemistry curriculum has a certain characteristic that makes it different from other technical courses: the higher amount of shared knowledge between different disciplines. As mentioned in the literature (McCowan, 2002, Wanks, 1995 p. 6), the classical teaching methods often fail in achieving the required fluidity between the curriculum subjects. By nature, an e-learning system allows modules from different disciplines to connect, and furthermore, to interact (Kartan et al, 2002).

Within this context we started our project of implementing an integrated e-learning system, with the following objectives:

- analysis of the existing information system regarding the possibilities to evolve into a proper e-learning system
- infrastructure development (hardware and software)
- design of the academic activity management system (software design based on authoring tools, personnel training, applications development for specific subjects)
- large scale system implementation
- technology transfer setting-up

This paper concentrates on the main characteristics of the e-learning system initiated in the Faculty of Industrial Chemistry, and the results obtained so far.

## 2 THE BASIC SYSTEM

Very often confusion is made between "e-learning" and "distance-learning". Distance learning can use the Internet, but also videotapes, books or other materials delivered by postal service. On the other hand e-learning doesn't necessary mean using the Internet as support. By e-learning it is generally understood a learning activity where ITC resources such as hardware resources (computers, routers, video projectors, acquisition cards, etc) and/or software resources (simulators, interactive multimedia applications, e-books, etc) are involved. The confusion between distance learning and e-learning generates a reticence to the models of the later, as many people fear that using these methods, the education process is depersonalised. This danger exists, but only in specific situations. From the point of view of trainer – trainee relationship there are three models of computer aided instruction systems:

1. "distance learning" model, based on Internet supported trainees-trainer interaction. Although there is the advantage of a great flexibility in managing trainee's time and material resources, there is the danger of depersonalising the educational process. The lack of the social component has severe negative impacts, such as losing essential information in the feedback process.
2. "face-to-face learning" model, assisted by ITC resources, characterised by extremely low flexibility and full social contact.
3. "combined" model, maximising the advantages of the previous two. It has a "face-to-face" component, since the trainee participates physically in the training classes (following a precise schedule), and a "distance" component supposing personal training sessions outside the academic training schedule, and even in other locations. For the "distance" component the Internet, LANs, and CD-ROMs can be used as support.

A large survey on the computer skills and attitude towards IT assisted education was conducted within the academic staff and student population. According to the survey conclusions we have decided to implement a "combined" model in our e-learning system.

While designing the system, we have established its main features:

1. **Interactivity**, the most important feature, ensuring efficient usage of the ITC resources by using the system specific functions. Considering our faculty's nature, we have insisted on dynamic interactions that give the user the possibility to modify certain parameters and visualise the effects induced. Among advantages one finds reducing the presentation delivery times and developing a constructive learning process.
2. **Administration**. This feature allows the e-learning system to include various technological and pedagogical functions: Web links, search engines, synchronous and asynchronous communication, course announcement areas, learner posting areas, learner records and interactions tracking or course management. They help administrating the learning process by bringing in automation, and offers a new flexible way of handling data to instructors, similar to how it helps learners handle their learning activity.
3. **Integration** since the industrial chemistry curriculum specifically asks for modules interconnection.
4. **Availability** as learners need to access easily data and administrators need the opportunity to use the administration feature remotely, from their home computer or an Internet Club. Internet-based, this function also helps promoting the system, thus helping the faculty gain access on the e-learning market.

The information support is an optical fiber network with 100MB/s transfer rate, structured on three levels (figure 1). Virtual networks are developed to avoid the topological limitation of the system hierarchy. The system has an open architecture to enable modification according to future technology development. The network can be the Internet, a local or an extended network. A wide range of technologies and environments will be used: distribution, audio, video, data environments, and interactive tools.

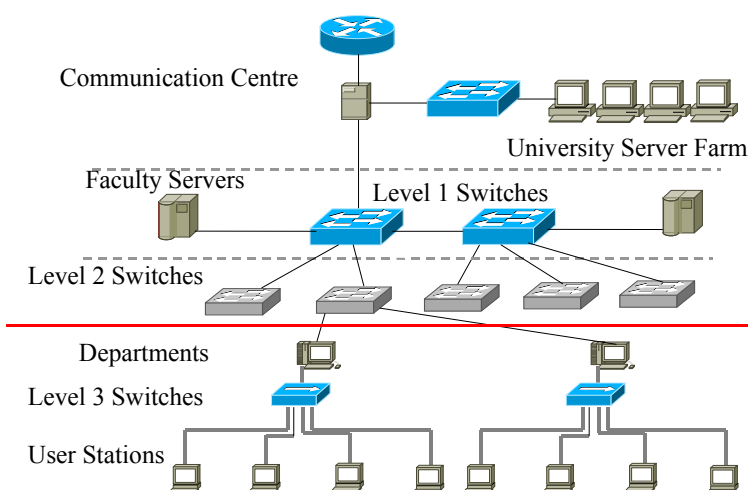


Figure 1. The network structure for the e-learning system

### 3 THE E-LEARNING SYSTEM

The system architecture, benefiting from the features mentioned before, consists of a two-element system architecture:

**-administration subsystem**, responsible for *administration*, *integration* and *availability* features. Web-based e-learning management tools alternatives (WebCT, Blackboard, TopClass, Virtual-U, Lotus LearningSpace, Web Mentor, etc.) did not meet the project requests or exceeded affordable prices. A new application was born (figure 2), developed by the Romanian software company, SIVECO SA, with experience in developing similar software products (High School Education Assistant-AEL).

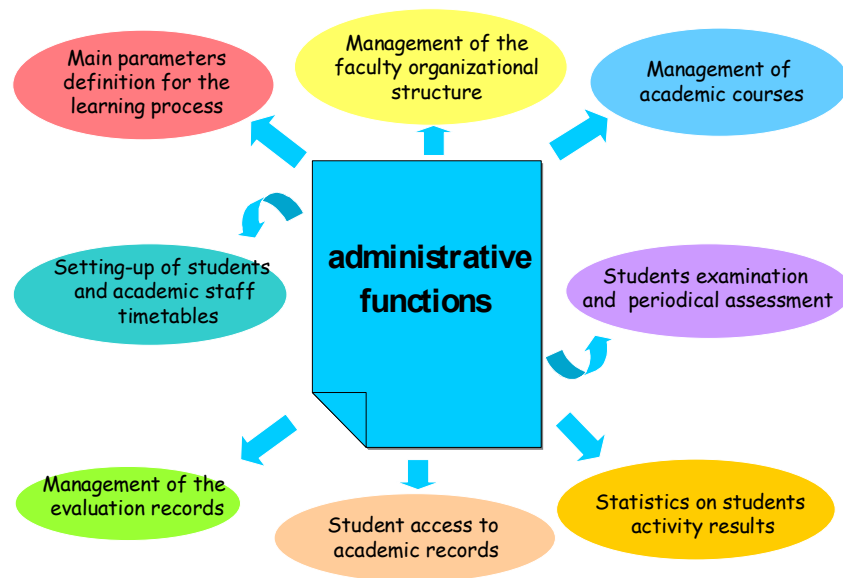


Figure 2. Administrative function of the e-learning system

The final product will be a complex software application (database / Java / html) that involves the server–client technology, allowing different user–level access, both vertically (system administrator / e–learning module administrator / teaching staff / students), and horizontally (teaching staff / content managers / administrative staff). The login pages are web pages accessible through a web browser.

- **content delivery sub-system**, responsible for the *interactivity feature*.

This subsystem is represented by several interactive multimedia modules developed in a specialised package.

#### 4 CONTENT DELIVERY SUBSYSTEM

The content delivery subsystem will consist mainly of interactive multimedia modules developed in Macromedia Authorware, a high-level product in the authoring class. It was considered an attractive package because of the following characteristics (Plesu et al, 1999):

- recording user information,
- delivery over the Internet: an application made in Macromedia Authorware works as any other classical software and runs by calling an executable file from the file package. It is also possible to deliver and run this application through the Internet.
- usage of media libraries (a special Authorware file containing a collection of individual icons and their content). Linking an application with one or many media libraries has several advantages: (1) the same content can be used repeatedly in one application without duplication; (2) once set up, a library can be used for more than one application; (3) media library content can be updated without changing anything in the main application.
- usage a wide range of user-application interactions,
- availability of a scripting language with 220 predefined variables and 300 predefined functions,
- tracking and recording users' performance.

The content development team has adopted a special working policy: depending on each department's needs, the content managers develop general rules for content modules, while a small team with more expertise in Macromedia Authorware software develop complex procedures (Plesu et al, 2001, 2002). Complex procedures are created at content managers individual requests, being adapted to fit the modules general rules. A library has been has solved two problems: a) it allows efficient distribution of all activities between people, considering their experience level; b) it avoids redundancy in the content developing activity.

The following content modules have been defined in the e-learning integrated system:

- *Assisted course-type modules*

They are the most important modules, representing the basis of the content library. They are used in lecture theatres and locations designated for these activities (e-learning laboratories).

The module scenario generally follows the teaching style of academic individuals. Thus, it shouldn't contain too many explanatory paragraphs. The scenario is non-linear and flexible. Hence, depending on the students' feedback, the academic has the possibility to control the content and switch between modules (seminary, evaluation, etc) within the same subject or even between different subjects. These modules are accessible only during lectures, under the instructor's supervision. Apart from the content delivery system meant to be developed in Macromedia Authorware, Power Point presentation were also included for lecture type modules.

- *Non-assisted course-type modules* follow the scenario of the assisted course modules, but are used for individual training. They include a large number of explanatory paragraphs, being available through the Internet, and other media (CD-ROM, floppy disk, etc.).

- *Seminar-type modules* contain problems and applications and may be used both in classrooms (seminars) and e-learning laboratories, as well as for individual study.

- *Lab-type modules* can be:

(a) Virtual lab type: the software simulates perfectly a process and allows processing of 'experimental' data obtained during the simulation;

(b) Real lab type, as the software allows processing experimental data obtained in a real experiment. There is also the possibility of collecting the necessary data automatically, using data acquisition cards. Visualisation of experimental set-ups is also possible, even from other locations by using video cameras. These two facilities solve problems occurring during classical laboratory sessions: problems due to lack of space, operation of dangerous equipment, etc.

(c) Semi-virtual lab type is a combination of the two mentioned above, in which a part of the studied process is carried out using experimental equipment and installations, while another part is carried out using simulations.

- *Evaluation type modules* allow tracking the students' performances by the academic staff, as well as self-evaluations during the individual training stage.

The next step after design and implementation of the e-learning system is to ensure permanent maintenance and continuous adaptation to the needs that may arise. Just like e-commerce does, the system has to identify the student's needs, find solutions, and reconfigure the appropriate modules.

So far, we have implemented assisted course-type modules and seminar-type modules for basic topics as programming languages, analytical chemistry, numerical methods, thermodynamics, unit operations and process simulation. According to the survey conclusions, the students consider that learning with computers should play a bigger role in their study courses.

## 5 CONCLUSIONS

We have presented the design of an e-learning system for a technical faculty that has administrative and educational functions and is still under development. The complete system implementation will facilitate both the faculty management and educational process.

## ACKNOWLEDGEMENTS

This work was performed in the frame of the Romanian National Research Programme INFOSOC, project no. 78.

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