

Blended Learning in Bioprocess Systems Engineering Education: Issues, Methods, and Applications

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Abstract

This paper addresses the issues, methodologies, and applications and the use of the Internet for Web-based delivery of knowledge and instruction in undergraduate biological engineering curriculum. This solution combines several different delivery methods, such as collaboration software, Web-based course delivery, and learning management systems. Some examples of Internet-ready instruction modules are presented to illustrate the blended learning approach. Lessons learned from past few years implementation of Web-enhanced courses in (bio)process system engineering will be discussed such as the setting up of self-developed “Learning Management System”, the implementation of virtual laboratories with animations and simulation features to enhance hands-on experiments in traditional labs, the development of distance-learning remote laboratories enabling students to set up the parameters that control an experiment using a Web interface.

Keywords: Blended Learning, e-learning, Learning Management Systems, Virtual Laboratories, Internet-Ready Instruction Modules.

1. Introduction

Information and Communications Technology (ICT) has largely reconfigured the learning panorama over the last decade. The Internet paves for the creation and adoption of new learning and teaching styles. Students and Professors have nowadays access to a much larger menu of resources to complement the classroom space. Blended Learning is learning which combines online and face-to-face approaches. Computer aided teaching strategies have been implemented to promote innovative learning and enhance student learning skills into the classroom. In the mid-nineties, a shift to the use of multimedia through PowerPoint® aided lectures has been put into practice to facilitate teaching and learning. Also, an interest in the educational delivery of coursework via the internet is being registered (Poindexter and Heck, 1999; Sureshkumar and Sato, 2000).

There are many ways in which internet-based activities can be integrated within a traditional course: online activities to study online learning resources; online tests to self-assess their own understanding of the subject; collaborative learning activities for students to work together on projects without necessarily being in the same room.

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The expression “blended learning” is being used to indicate the combination of various event-based activities, including face-to-face classrooms, live e-learning, and asynchronous self-study. Blended learning combines several different delivery methods, such as collaboration software, Web-based course delivery, and learning management systems.

A number of initiatives are underway currently to use ICT in the classroom. For instance, the “e-U” (Electronic University) Portuguese project, based on a network of virtual campus, is intended for the production and sharing of online academic contents to gain access to classes, R&D articles, student papers, grades, and academic administrative services online, as well as access to the internet through a broadband wireless LAN. A task-force at the University of Minho was started with a seed project to promote the development of courseware to supplement the curriculum.

Virtual labs are becoming a popular way to reduce equipment costs or to learn about cases too dangerous to conduct in laboratory such as explosions. Virtual labs bring laboratory concepts into courses where it would be otherwise infeasible. These types of labs commonly use LabVIEW[®], MATLAB[®] or Simulink[®] for the simulation software (Joseph et al, 2001; Shin et al., 2002; Yabo and Miaoliang, 2002). **Remote labs** are genuine laboratory experiments that are run remotely via a Web interface (Paiva et al, 2001). LabVIEW[®] offers a software platform for development of distance-learning remote laboratories enabling students to set up the parameters that control an experiment using a web interface.

These new educational tools and methods can be used to enhance the quality of biological and chemical engineering education (Varma, 2003). In a recent initiative (MIT, 2003), virtual labs for core courses, **Internet-ready instruction modules (IRIM)**, interface curriculum with software applications libraries were identified and proposed as the main tools and mechanisms to advance the undergraduate chemical engineering curriculum.

This paper will address the issues, methodologies, and applications on the use of the Internet for web-based delivery of knowledge and instruction in undergraduate biological engineering curriculum vis a vis conventional chalkboard learning. Also, the development of software and computer assisted instructional modules (IRIM) will be presented.

2. Implementation of web enhanced courses

Since I started teaching in the early nineties that computer assisted instructional modules are being integrated in my different courses. In the mid-nineties, a shift to the use of multimedia through PowerPoint[®] aided lectures has been put into practice to facilitate teaching and learning. With the advent of Internet, also in the mid-nineties, endeavour for web-based delivery of knowledge and instruction in undergraduate biological engineering curriculum was put in practice.

Although that developing Web-based training was a far reach from our core competency of developing traditional classroom training, the challenge was to produce web courses that offered more than the average page-turner tutorials. The asynchronous learning modules were authored using packages as Microsoft Frontpage[®] and Macromedia Flash[®]. Also, in the absence of commercial “Learning Management System” (LMS)

solution, a decision was made to setting up a self-developed LMS for course administration information and materials distribution. A Web site template was developed using Microsoft Frontpage® to centrally house various online functions and facilitate course management. For each course students easily access announcements in the entry page, weekly course outline, teaching materials (e.g. lecture handouts and presentations), syllabuses and study guidelines, schedules of lessons, instructors' contacts with attendance hours, class and study problems. The course dossier is also made available that includes: schooling, credits, goals and prerequisites, evaluation, regimen of lacks, grading, bibliography, summaries, and list of enrolled students. Additionally sections are Frequently Asked Questions (FAQ) and granted access to a discussion forum where students can post questions queries and share documents. Students can also download the examinations of previous years and browse classifications in current examinations. A selection of interesting Internet links with related information sources complements the LMS. An example of a typical Web-enhanced course is shown in Figure 1. This site is hosted by the e-LEB portal (www.biologica.eng.uminho.pt/eLEB) where several web-based courses are straightforward available for online access. e-LEB stands for e-Learning in Biological Engineering undergraduate degree at the University of Minho. The author is in charge of two courses related with Process System Engineering (Control and Instrumentation, and Strategy of Process Engineering) and two courses on Pollution Control (Wastewater Engineering I, Air Pollution) all with identical LMS and IRIM tools.

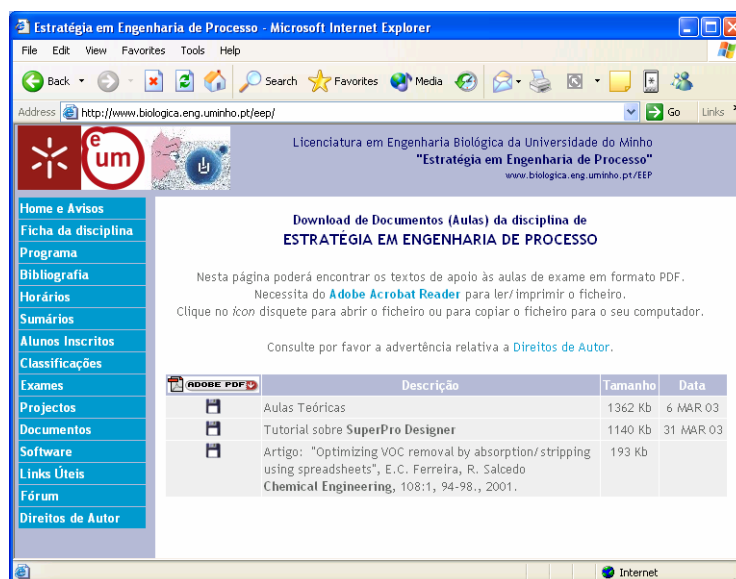


Figure 1. LMS for the web enhanced course in “Strategy of Process Engineering” (in Portuguese). The navigational bar of links is always displayed in site to switch between topics. Students use these links to access announcements, syllabus, the course dossier, and other course materials.

3. Internet-ready instructional modules

The Internet is also indicated for web-based delivery of knowledge and instruction by allowing students to download software and computer assisted instructional modules to run as homework exercises. Additionally, some active students are participating in the development of these **Internet-Ready Instructional Modules (IRIM)**, thereby providing them valuable hands on experience with the use of ICT tools.

In the case of Wastewater Engineering with laboratory practical classes, additional materials are given to enrich, prepare, and assist the students both in the laboratory and before they come to lab: classes outline, wastewater laboratory procedures with critical and important instructions and tips on how to perform laboratory analysis on wastewater, brief theoretical introduction, multimedia video clips, and links for information sources. The multimedia material integrates, besides some photos, a digital video with the main steps of the work in accelerated time (Fig. 2). The development phase of this IRIM involved a group of students. This interactive demo coupled with animated diagrams of instruments is regarded as a **Virtual Lab** a software simulation of a physical experiment. Although we do agree that no simulation can really replace the hands-on experience of the student in the lab, it can be a good substitute for an actual lab, especially if it is accompanied by animation.

Another approach is the **remote control** of experiences. A lab-scale plant integrating wastewater treatment to remove organic matter and nitrogen is used to illustrate monitoring and control of a biological wastewater treatment process. A supervisory computational environment for data acquisition, plant operation, and distributed equipment control was developed using the LabVIEW[®] graphical object-oriented package. Front panels of the supervisory program are published to the Internet for use in a common Web browser turning the application into a distance-learning remote laboratory. Students on the Internet with the proper permissions can access and control the lab-scale plant using the free LabVIEW[®] run-time engine installed on the client computer. Visual feedback is also provided from embedded live images captured from ordinary webcams.

An IRIN for dynamic simulation of the anaerobic digester (Bernard et al., 2001) in a wastewater treatment plant has been developed using LabVIEW[®]. A graphical user interface is used to run the simulator and to present the simulation results in real time. This simulator has been used for educational purposes in Wastewater Treatment course and resulted from the development of some active students.

In the afore-mentioned course of “Strategy of Process Engineering” a **software application library** of spreadsheet case studies for teaching practical optimization and design concepts is made available. These case studies illustrate how the Solver of the Excel[®] is used for the optimization of several chemical engineering systems, including pollution prevention problems, process synthesis including heat integration and solvent recovery, and mass-exchange networks (Ferreira et al, 2004; Ferreira and Salcedo, 2001a; Ferreira and Salcedo, 2001b). This course also entails collaborative learning activities for students to work together on project design done outside class hours and requires a considerable amount of group effort on searching information sources, data collection, and calculations.

4. Conclusions

It is often said that putting handouts online doesn't constitute online learning - and that is true - handouts don't teach - but they do support learning, and the technology is being used in this case to create a more accessible course repository.

The self-developed framework for expanding pedagogical approaches to enhancing web-based instruction is a continuous development effort. The perceptions of the outcomes of using online technology in my courses helped me to identify future steps that might take to make improvements. Specially, the development of knowledge-based and perception-based assessment mechanism for both formative and summative evaluations is envisaged.

With the widespread of wireless notebook computers, handheld PDA, and tablet computers in education the push to provide better online learning resources is becoming a new paradigm – mobile learning. Everything is available with a laptop and from any point within the university campus. Typically, elearning is described as being "anytime, anyplace learning". While this is mostly true, a student still needs access to a computer with Internet connection. M-learning can happen everywhere. The infrastructure and tools are in place for m-learning.

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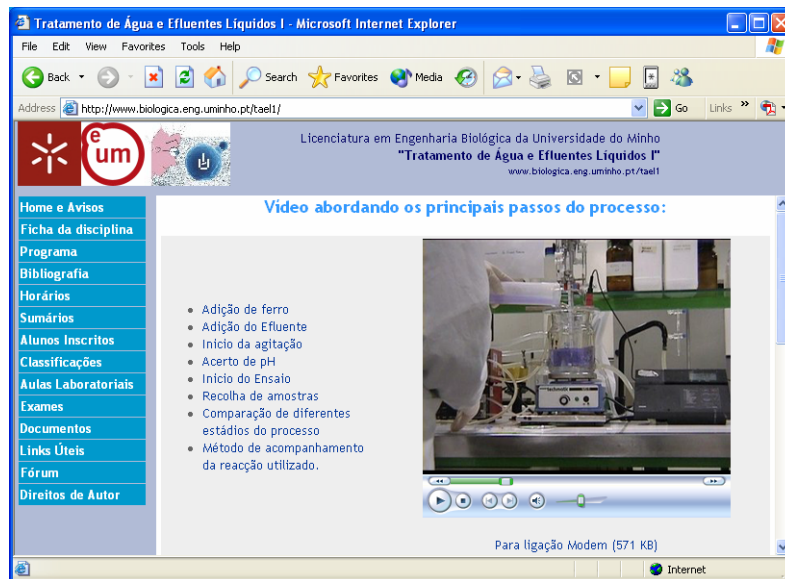


Figure 2. Wastewater treatment virtual lab: multimedia digital video clip with the main steps of the work in accelerated time.



Figure 3. IRIN for dynamic simulation of the anaerobic digester in a wastewater treatment plant developed using LabVIEW®. Model and data adapted from Bernard et al., 2001.