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WEB BASED ENGINEERING EDUCATION

Sheikh, Sharif Iqbal[1], Junaid Siddiqui[2]

1: Assistant Professor, Electrical Engineering Department, KFUPM.
2: Lecture, ADC, KFUPM.

E-mail: sheikhsi@kfupm.edu.sa , junaids@kfupm.edu.sa

ABSTRACT

The use of Internet for distance education has received increasing attention over the past few years. But the real challenge of adapting this technology for engineering education is to facilitate the laboratory experiments via Internet. This paper discusses the software and hardware requirements of virtual courses/laboratories to provide interactive environment for designing and conducting classes/experiments. The examples provided demonstrate a virtual laboratory for Electrical Engineering courses and shows how similar laboratories can be implemented for other courses like Chemical Engineering, Mechanical Engineering and System Engineering etc. In a traditional university environment, virtual labs can also improve the Engineering curricula in a cost effective way by establishing a timely connection between theory and practice. The obstacles in introducing engineering education via digital media are also discussed.

Keywords: *Virtual laboratories, Internet universities, Virtual classes, Web courses*

الملخص

استخدام الانترنت للتعليم عن بعد لقي إقبال متزايد في السنوات القليلة الماضية. لكن التحدي الحقيقي لتكييف هذه التكنولوجيا في دراسة الهندسة هو لتسهيل تجارب المعامل الفعلية عبر الإنترنت. تناقش هذه الورقة العلمية البرامج والأدوات المطلوبة للمواد والمعامل لتهيئة البيئة التفاعلية وإجراء التجارب . إن المثال المطروح يوضح تجهيزات معامل الهندسة الكهربائية والتي يمكن تطبيقها أيضا في تجهيز معامل الهندسة الكيميائية والميكانيكية إلخ.. إن المعامل الفعلية في بيئة الجامعة التقليدية يمكن أن تحسن المقررات بأقل كلفة وذلك بإجراء توافق زمني بين النظرية والممارسة العملية. ولقد ناقشت هذه الورقة أيضا العقبات التي تعترض تقديم العلوم الهندسية من خلال الأوساط الرقمية

1. INTRODUCTION

The rapid advancement in educational tools experienced over the recent decades makes it difficult for engineers to keep themselves abreast of the current technology. Concurrently, increasing number of undergraduate and graduate students, taking up engineering education, are overloading the traditional universities [Carol, 2000]. With limited resources, little can be achieved in extending or introducing new facilities that will cater for the prospective students in the conventional way. To remedy this situation, many countries allowed the establishment of private technical universities. But due to their high tuition fees, they are outside the reach of average students. Another economical approach is the creation of open learning centers, like Open University. But its video courses, unless delivered real-time over dedicated satellite or network connections, provide very little interaction between student and teacher. Recently, with Internet becoming a viable educational media, the concept of online teaching has radically changed and can significantly contribute in solving the enrolment problem [Tom, 2000] though the introduction of Internet based Virtual University has become successful in many subject areas, virtual classrooms still require efficient technologies for establishing interactive and online form of laboratory experiments, essential for engineering education. In this paper, different ways of exploiting Internet technology in creating suitable environment for interactive online engineering education [Danielle, 2001] are discussed. The software and hardware requirements for such an institute are listed. Examples of virtual laboratories, essential for distance engineering education, are demonstrated.

2. FORCES DRIVING CHANGES IN ENGINEERING EDUCATION

Advanced electronics and computer technologies are revolutionizing today's industries and creating pressure on the engineering universities to modernize their programs to meet the challenges or to maintain the accreditation of the programs [Ehrmann, 2000]. Several factors that are forcing us to re-evaluate the structure of graduate/undergraduate engineering education are discussed below;

2.1. Technological Revolution

Due to the revolutionizing advancement in electronics and computer technologies, traditional engineering universities have experienced a sharp rise in student enrolment. With limited recourses, modernizing the educational structure using recent Web-based resources seems to be the only way to cope with the further increase in the student-to-institute ratio.

2.2. Need for Continuing Education

In today's rapidly changing work place, the concept of an abrupt end to education at the completion of college studies is disappearing and the need to acquire new skills and advanced education throughout the career is becoming essential [Jeanne, 2001]and [Paul, 2001]. These cross-functional and cross-skilled requirements are making a potential student out of every

technician/engineer and needs a commitment on the part of engineering institutes to provide such opportunities. Using limited capabilities of the existing educational system, it is very difficult to cater the need of individuals and require a modernization of the educational structure.

2.3. Diversity

Diversity among engineering students and their requirements are always increasing with new inventions and ideas. Traditional technical institutes cannot cope with this increase without massive investment in infrastructure and workforce. Thus to address the students with different needs, goals, backgrounds and ages, engineering universities need to renovate its operating policies.

3. VIRTUAL ENGINEERING UNIVERSITIES

The use of Internet and virtual classroom is an emerging trend in upgrading the curricula with no added investment for infrastructure. According to [Chickering, and Ehrmann, 1994], Internet provides a rich educational environment which has almost all the required tools necessary to implement the principles of good teaching [Chickering and Gamson, 1987]. It provides a variety of tools that can accommodate the diversified requirement of individual student or working-professional in a cost effective manner [John, 2000]. Also due to the adaptive nature of the web-based learning, they can be customized to meet the needs of learners with different backgrounds and age groups.

3.1 Online Engineering Education in KFUPM

For several years, many departments in KFUPM are using online tools to enhance and supplement the traditional classroom style education. Course homepages listed in the Web or dedicated servers in the network are utilized to distribute syllabus, semester schedule, class notes, assignments and other course material. Using a microcomputer, telephone line and web browser students can access these materials at their own convenient time from any location and download them at a minimal cost. Recently, the introduction of WebCT and Blackboard software's in the system has enabled students to submit the solutions of assignments, home works and take quizzes via Internet. Thus so far the online education in KFUPM, like many western universities [10], is only implemented to complement the classroom based lectures.

3.2 Proposed Virtual Engineering Institute

Internet based virtual universities, on the other hand, are distance leaning centers that eliminates the barrier imposed by time and distance. Using Internet based synchronous or asynchronous technologies; virtual universities can cater for the educational needs of Saudi men and women residing in remote parts of the country. In this system, off the shelf

software's like, WebCT or Blackboard, can be used to design virtual classrooms [Danielle, 2001] and laboratories [Anderson, 2000] to deliver the complete course material to student, who have the flexibility of going through it in their own convenient time from a suitable place. While this flexibility is unprecedented, it requires greater than average discipline on the part of the student to continue the degree program. The hardware requirements of a typical virtual institute, from file server to student computer, are shown in Figure 1. The characteristic and affiliations of several leading software's used in designing virtual environment are summarized in Table 1.

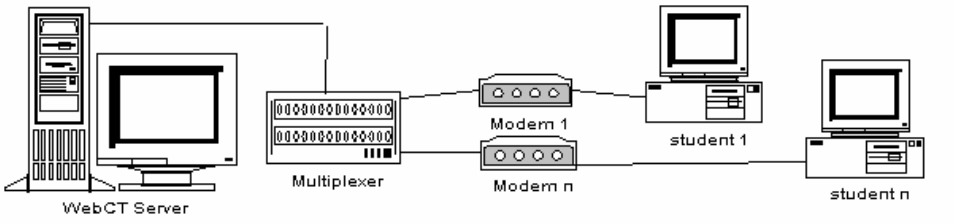

Figure 1: Typical hardware setup for virtual institutes

Table 1: Leading Software's for Virtual Course Management system:

Software's	Characteristics	Affiliations
Web CT	Provide campus learning environment for distance education	Estimated in use at 2600 institutes
Blackboard	Software for online learning environment	Used by more than 1900 institutes (estimated)
Lotus Learning Space	Provides Web platform for training and e-learning	600 Campus license, (*Siemens-Virtual,Wisconsin University*)
eCollege	Provides online campus for virtual universities.	Univ. of Colorado, Johns-Hopkins, Seton Hall etc.

3.2.1 Pedagogical Consideration

As a first consideration in developing a web-based course [Media Design and Assessment, 1999], the designer should gather as much information as possible relating to the background and the capabilities of the intended audience. The next consideration should be given to curriculum organization. The presentation of course material, streaming media presentation, homework problems, quizzes etc. should be arranged as such, that the audience could enjoy

the learning process. While designing streaming presentation, the likelihood of audience having slow and unreliable connection should be considered. Course modules should be short and its concepts frequently reinforced via homework and self-test quizzes. For virtual laboratories, design criteria should include relevance, reliability, guidance and ease of access (via Explorer or Netscape). Thus, the success of a virtual institute often depends on the quality of training given to the instructors to cope with the challenges of digital teaching media.

3.2.2 Internet Course Delivery

The options available for Internet delivery of educational material are vast [Anderson, 2000]. Some of them are as follows; Java scripts; HTML only; HTML with synchronized audio; HTML with audio and Flash animation; Streaming videos only, Streaming video synchronized with HTML presentation, Flash animation, Java enhanced pages etc. Over a modem, the poor quality of a sustained video stream often makes it more distracting than useful. A straight HTML based presentation can be effective, but it is difficult to design virtual classes that convey enough information in an engaging manner. Many virtual institutes prefer HTML with synchronized audio, but HTML with audio and animation results in presentations that can be more engaging and streamed over low capacity connections. Some of the above delivery method will be demonstrated in the presentation of this paper.

3.2.3 Virtual Lecture Classes

The Many popular courses, like business administration, management, accounting, marketing, nursing, computer science, information technology, education, linguistic etc., are already offered by many virtual universities in the developed world [James, 2000]. Typically, in a virtual environment, a student can concentrate on one course at a time, and when a course is completed he or she can move on to the next one until all degree requirements are met. Each online course probably can last five or six weeks with students devoting an average of fifteen to twenty hours a week to their studies [Jeanne, 2001], [Paul, 2001],[John, 2000] and 10]. When necessary, students can ask questions to the instructor and participate in the class discussion using computer conferencing or email messages. In this way they can send comments and receive feedbacks from other students in the class. Assignments and projects can be submitted individually or by group to the instructor, who corrects and returns them with comments. Interestingly, in such a class, the group can consist of students from different parts of the country. When quizzes are due, the students can also take them online, where cheating can be some what controlled using various methods available in the software (WebCT, Blackboard etc.). For mid semester and final exams, short time examination centers can be introduced throughout the country, where online/offline examinations can be arranged. A WebCT based Virtual course in electrical engineering, designed in KFUPM, is shown in Figure 2.

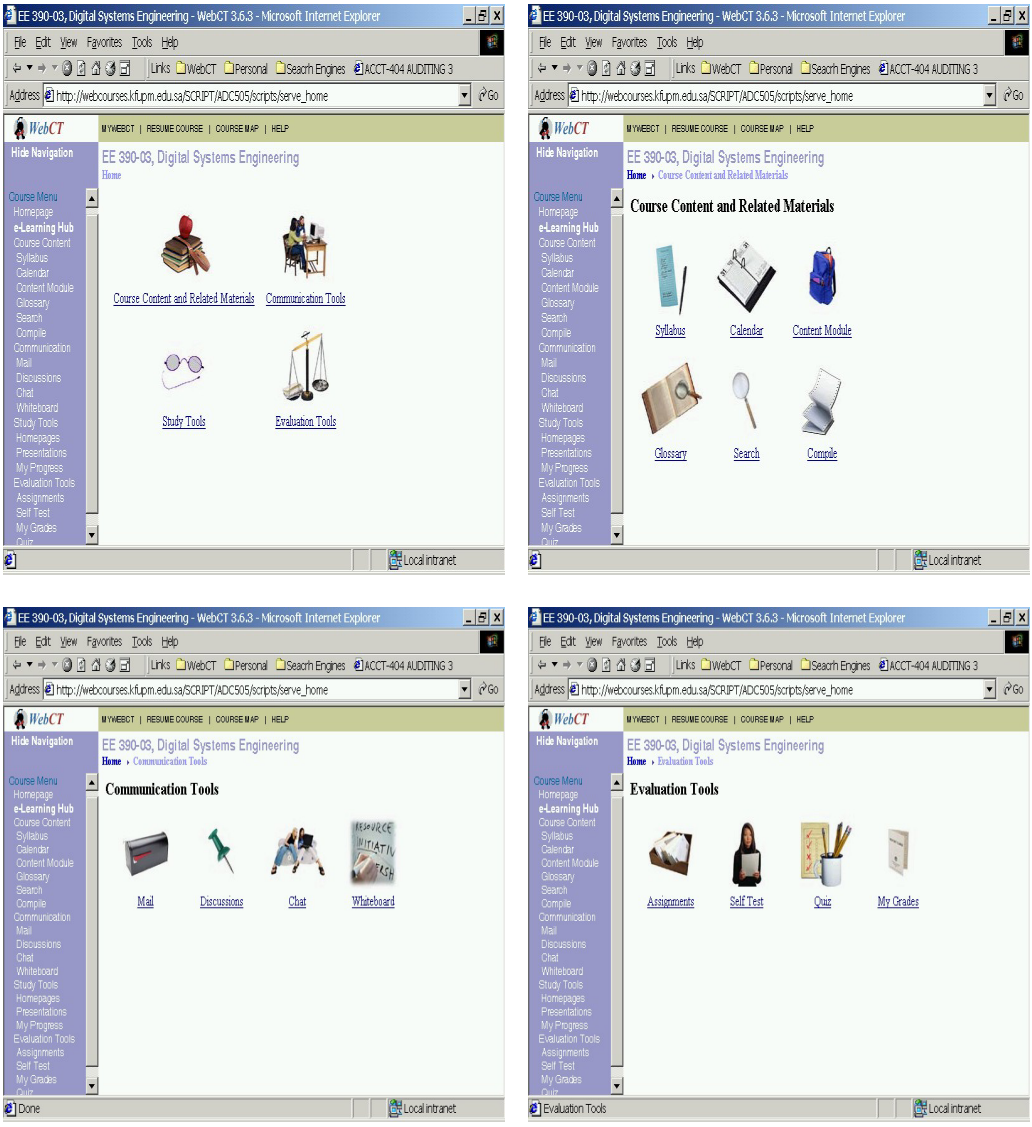

Figure 2: The outline of a WebCT based virtual course engineering course (EE 390 of KFUPM).

3.2.4 Virtual Laboratory Classes

Two possible realizations of interactive virtual laboratories are presented here. The 1st method involves software's with powerful programming development environment for data acquisition and control, data analysis and data presentation. The 2nd method is based on the Internet Server Application Programming Interface (ISAPI) extensions. In this technique, advanced functionalities of modern Web browsers and servers can be utilized that allows data

transmission in several suitable formats for presentation and analysis of virtual labs. Added advantages are the ISAPI filters, which perform useful tasks related to security, queuing and logging etc. [Fjeldly, 1999]. In this section, the 1st method is adopted to demonstrate interactive laboratory, where virtual instruments with front panel user interface that may contain numeric displays, meters, charts, advance graphs are used. As an example, 'LabVolts' award winning virtual instruments for electrical engineering laboratories are shown in figure 3 (a) & (b).

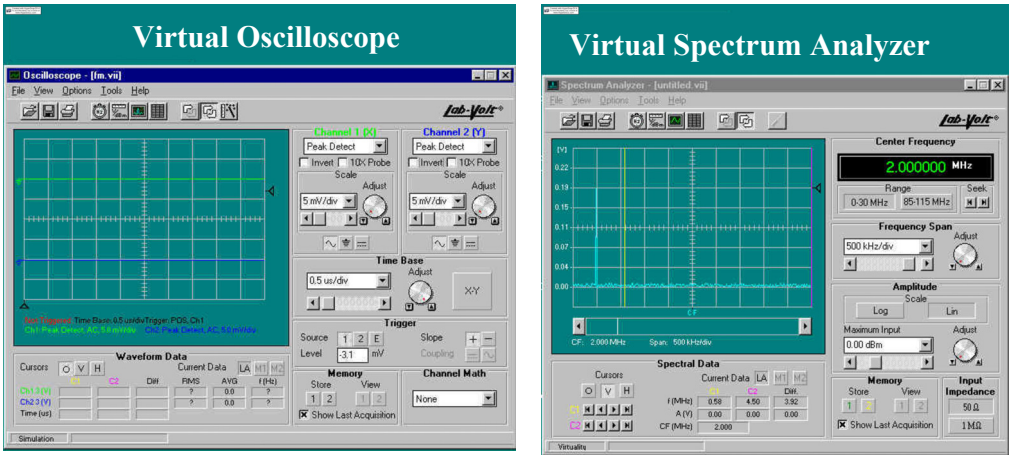

Figure 3(a): Front panel of a virtual Oscilloscope & Spectrum Analyzer used in EE labs.

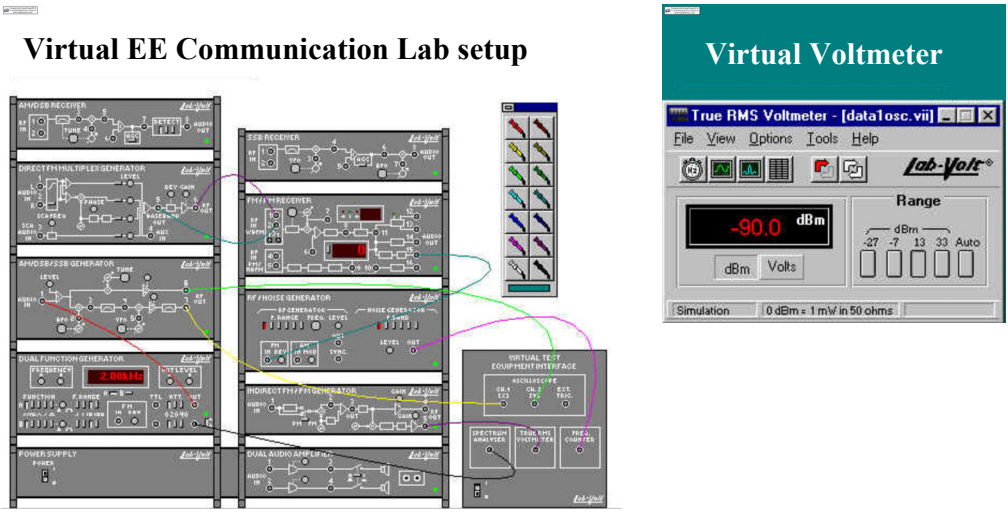

Figure 3(b): Laboratory setting for a virtual EE lab and the front plane of a virtual Voltmeter.

3.3 Students Services in Virtual Institute

In this virtual university, students can access research material from the University's Electronic Library. They can also find out their exam results, grade point average (GPA), academic record and scheduled of courses or other official announcements via Intranet. The registration process can also be done online.

4. EXISTING VIRTUAL COURSES AND LABORATORIES

The University of Phoenix (UPO), USA can be cited as an example where Intranet based distance education medium offers unparalleled convenience and flexibility to students in attending classes from their personal computer. In UPO, students working in small groups of eight to thirteen, or working one-on-one with an instructor, can discuss issues, share ideas, test theories essentially enjoying all of the advantages of an on-campus degree program, with few important exception. Table 2 summarizes and characteristics and the distance courses offered by several virtual universities in USA.

Table 2: Virtual Universities:

Institute	Characteristic	Number and Type of Distance Education (DE) programs	DE Enrolment
John International University	1st fully accredited online university	21 Certificate; 1 Bachelor's; 2 Graduate	~ 1500
University of Phoenix Online	Fastest growing online university	8 Bachelor's; 10 Masters; 1 PhD	~ 18,500
West Governors University	Private online university	3 Certificate's; 4 Bachelor's; 1 Graduate	~ 208

Currently, in the field of engineering a number of excellent virtual laboratories are available through the Web and their education potential can be used globally. Table 3 provides a list of virtual laboratories (with Web addresses), developed and used (in some cases) by well-established institutions. However, it is important to use these virtual media wisely, as otherwise it may lead to loss of creativity, imagination, interpersonal skills and discipline among students. In traditional university environment, these virtual laboratories can also be used to supplement and enhance classroom laboratories and lectures.

Table 3: Virtual Laboratories:

Subject	Course	Web Addresses (URL's)
Electrical Engineering	Semiconductor Physics	http://ostc.physics.uiowa.edu/~wkchan/MATERIAL/
	Electromagnetics	http://www.gmi.edu/~drussell/Demos.html
	Neural Networks	http://www.aist.go.jp/NIBH/~b0616/Lab/Links.html
	Electronics	http://jas.eng.buffalo.cdu/applets/education/
	Control System	www.esr.ruhr-uni-bochum.de/esr/cs/vclab/vclab.html
	Signal Processing	http://hompages.udayton.edu/~westerka/applets.html
	Communication	http://www.comapps.com.au
Mechanical Engineering	Thermodynamics	http://jersey.uoregon.edu/vlab/Thermodynamics/index.html
Chemical Engineering	Fluid Mechanics	http://www.cwr.uwa.edu.au/cwr/teaching/fmLabs/fm_labs.html

5. CONCLUSION

Many engineering universities are currently under pressure to develop Web based online courses using virtual classrooms and laboratories. Since educational environment of the virtual institute is drastically different from traditional universities, it is important to design, develop and assess the web-based multimedia learning resources. The main challenge in implementing virtual engineering institute is the implementation of online laboratories for interactive experimental work. Well known software producers (LabVolt, LabVIEW etc.) and universities have already developed online virtual equipments to carry out the experiments in many field of engineering. In this paper, examples of virtual equipments that can be used in electrical engineering laboratories are presented. Several URL's are listed in Table 3, where virtual laboratories for many other engineering courses can be found and used. Although, at this point, there are more questions than answers, there is a definite need for discussion; brainstorming and exchange of ideas before Internet based engineering universities can be implemented in Saudi Arabia.

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