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A computational hypermedia teaching and learning environment in engineering education

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Abstract
Recent concerns about the quality of graduates in engineering has generated increased attention on the relationship between teaching methods and learning processes in engineering curricula. According to Professor Clyde, the taskforce chairman of the current engineering education review, "Australian universities are failing to equip engineers with the skills needed to survive the computer age". He adds, "the impact of computers has become pervasive enough to warrant restructuring the engineering curriculum".
The development of a computational hypermedia environment for education requires significant expenditure of time. In return many students develop information literacy skills, appreciate the effort and may find the subject interesting and fun.

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The American National Science Foundation (NSF), our ARC equivalent, has recently announced the availability of about $2,000,000 funds in 1997-1999 for research and development projects in Electric Power Systems Engineering education. The overall objective of this initiative is to examine long term educational problems and needs, generate solutions, implement them into innovative curricula and develop educational tools such as simulation programs and visualisation tools to make the learning process of Electric Power Engineering more effective and intellectually stimulating. Emphasis will be placed on development of innovative educational tools and simulating an environment for active rather than passive learning.

Traditionally, engineering subjects are taught by using a pen and paper approach. For ease of analysis, the system under investigation is often represented by a crude approximation. Analysis techniques are then applied to this vastly over simplified model. This normally will not result in a "faithful" representation of the actual behaviour of the system in real life. This method of instruction has been employed, as engineering educators well recognise the fact that:

it is expensive to provide a "real life" working model of a system and

even if a scaled down model of such a system is available, it is difficult for the students to appreciate its dynamic behaviour as it is impractical or impossible to measure all the important variables associated with its operation.

In experimental science courses, computer simulations may be used to represent the essential features of a real system so that students can test their analytical and design skills in a convenient, inexpensive and safe environment. In a well designed computer simulation-based teaching and learning environment students have access to all the internal variables of the system; they can view them at will, appreciate their dynamic variations, as well as being guided in a step by step manner in appreciating the subject, by solving problems arising from the operation of realistic case studies. It has been shown that this will ensure the development of two fundamental learning outcomes namely "conceptual" and "intuitive" understanding of the subject matter.

A computer simulation-based teaching and learning method for an elective subject in electrical engineering was developed and implemented in the Department of Electrical and Computer Engineering in 1993. Extensive support resources, including lecture materials, small design, analysis and planning projects as well as tutorial questions, were prepared and have been used ever since. Pedagogical principles of a computer simulation-based learning method, applied to engineering education, and all aspects of the subject development have been documented. The
work clearly showed, among other things, improved
progression rates as students found sufficient stimulation
and challenge and hence they seemed to enjoy the
methodology and the contents.

Recent introduction of powerful information retrieval tools
and methods has demonstrated the great potential of the
Web technology in various aspects of tertiary teaching and
learning. The technology provides flexible access to a wide
variety of information by incorporating the notions of
"navigation" and "tailored presentation". They also allow
students to use a variety of teaching support materials,
including computer simulation programs and computer-
aided tutorial modules, in a coherent and more meaningful
way. Students may operate on different platforms, different
operating systems, and they have the choice of stand-alone,
Internet, or combined mode of operation. The network
option also makes available standard tools such as the
electronic mail and discussion groups that could be used to
provide off-line interactions between students and lecturer
as well as among students themselves.

The favourable outcomes of the computer simulation-
based teaching and learning strategy and the distinct
advantages of the Web technology when it is used as an
educational delivery tool promoted a new research and
development project in "applied engineering education
technology" in early 1994. This project aimed to develop a
fully integrated computer-based engineering education
working model centred around what is commonly referred
to as a "computational hypermedia environment". This is a
computer generated learning mode where computer
simulation programs and other types of media files, such as
text, static images, animation and sound, are fully integrated
to provide a flexible access to a wide variety of information
(media files) along with stimulation, challenge, realism and
fun for the learner. The resulting model maximises the
utilisation of our campus-wide computer network
infrastructure that operates on the very latest network
technology; allowing advanced integration of sound, video
and data files traffic.

This project produced the following four modules for the
target engineering education working model. These
modules use, among other things, the Web as a prime
information retrieval and visualisation tool, campus-wide
computer network, computer-aided tutorial resources and
educational computer simulation programs:

1. A computational hypermedia platform for publishing
engineering resources,
2. an integrated environment consisting of different
media files used in science and engineering laboratory
classes,
3. integration of computer simulation programs into the
engineering curricula for the development of
conceptual and intuitive understanding of
multidisciplinary engineering subjects; and
4. the use of the Web technology as a flexible delivery tool
in support of lecturing to large classes on campus.

The implementation of the Web as a publishing platform
for engineering education resources resulted in a major
"hyperbook" development. This initiative provides
engineering support materials for undergraduate and
postgraduate students as well as researchers and practising
engineers. It is interesting to note that the Internet tools and
resources are being used for the project co-ordination and
for the exchange of information among the authors who are
working at five different universities in two countries. The
science and engineering laboratory courseware delivery
module illustrates the integration of experiment
instructions, computer-aided laboratory resources, that
were developed using the Authorware program, Data
logging and data post-processing software, and computer
simulation programs. The modules of the proposed
engineering education working model can be used in a
diverse range of electrical, mechanical, civil, chemical and
environmental engineering courses.

To demonstrate the effectiveness of the Web technology
when it is used to support lecturing in large classes on
campus, the relevant module was adapted to deliver
"Electrical Engineering 1", a first year compulsory subject
with 100 plus students. A combined "simulation-based
teaching/learning and course content coverage" method
was designed and implemented in 1995, and further
improved in 1996. A freely available student version of an
electric circuit simulation program (PSpice) was integrated
into the subject, and the University campus-wide computer
network was used for delivering subject resources that
include full text and pictorial content of lecture
presentations, tutorial questions, assignments, sample
computer simulation source codes, sample simulation
results and discussions, and simulation programs as well as
other relevant freely available utility software.

Students access the ELEC101 Web site that lives at the
University Web server to study (or to print) lecture material,
to work out tutorial questions, to browse results of sample
simulation runs, to run simulation on sample circuits, and
to retrieve their sessional computer simulation assignment.
Moreover, part of the ELEC101 course delivery was
conducted using the Web as a replacement for the overhead
transparencies and/or Microsoft Power Point pages in the
lecture theatre. This gave the advantage of on-line access to
other support resources such as the simulation program and
data post-processing and waveform display software.

Students also have access to all resources not only for
The development of a computational hypermedia environment for educational purposes requires significant expenditure of time for the course pedagogical studies, and for preparation of course resources. In return, it can be seen that many students appreciate the effort and many find the subject interesting and fun. All these have been reflected in the results of the students' teaching survey that was conducted this year. In brief, the use of new educational delivery tools and methods showed that the technology could:

* generate enthusiasm for the subject matter,
* reduce lecturing hours so that academics spend more time in course development, and greater numbers of courses are taught in existing lecture theatres,
* provide students more freedom and choice in retrieving subject resources,
* help students to develop computer and information literacy skills not only because they are required by the University rules but also because they are key elements of their tertiary education, and
* eliminate the old note-taking ritual that has been around since the days of Socrates.

The development of the engineering education working model will be continued in the future by focusing on:

* "Java language and apples" so that interactive features are incorporated into the conventional hypermedia environment,
* "Shockwave platform" that allows users to view and interact with multimedia modules such as Authorware-based computer aided modules on the Web, and
* developing/adapting "plug-in programs" to extend the capabilities of the Web browser in handling educational computer simulation programs.

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References


