Teaching Introduction To Electric Circuits Using Computer-Based Instruction For Manufacturing Engineering Students

Nizar Al-Holou and Mahmoud Abdallah
Electrical Engineering Department
University of Detroit Mercy
4001 W. McNichols Rd.
Detroit, MI 48219-0900

Abstract

We are developing an electro-physics curriculum which integrates the fundamental contents of conventional physics with electric circuit. In this paper we will discuss the difficulties and the challenges associated with using CBI to replace some aspects of traditional classroom learning.

Introduction

American industry face stiff competition in today's world markets. As competition increases, industry search for ways to produce more at lower cost with higher quality. The long-term key to improve productivity and competitiveness is education. However, there are difficulties associated with using the prevalent classroom system for continuing learning. Such difficulties include traveling distance between work place and university; interruption of work schedules; and difficulty presenting the latest information and technology.

As a result, American industry and some universities have collaborated to build modular educational programs that allow employees to improve their education and knowledge without interrupting their work schedule, and thus increase the company's competitive edge. The challenge is two parts: First, develop and bring multimedia-enhanced courseware into the workplace as well as classroom. Second, interactively 'narrowcast' state-of-the-art lectures into the employees' work place, home, and ultimately onto their desktop [1-3].

Two approaches are being evaluated at many schools across the country. The new methods are known as Computer-based Instruction (CBI) and Interactive Distance Learning (IDL).

Course Structure

There are several commercial packages available in the market that address the circuit analysis topic. However, these packages are considered to be either tutorials or supplements. Our development is very ambitious where the developed module is stand alone module. i.e. it could be used instead of a text book or a text book can be used as a supplement.

Moreover, case studies from manufacturing facility at Focus:Hope's Center for Advanced Technologies (CAT) will be used to illustrate the concepts. Also, commercial packages have been developed for electrical engineering majors only whereas our module covers the concepts needed for non majors [4, 5]. Furthermore, our approach provides tracking of the students' progress in the curriculum as well as on-line testing. Moreover, this is the first CBI development which integrates the fundamentals of physics and electric circuits designed for manufacturing engineering students.

We are developing an electro-physics curriculum which integrates the fundamental contents of conventional physics with electric circuit. This includes the complimentary concepts of electricity and magnetism from physics and the relevant electrical engineering concepts as used in manufacturing technology and engineering practice. The introduction to electric circuits course, includes nine topics: electric circuit demonstration, Ohm’s law, Resistors, measurement devices, power, DC circuits, parallel circuits, series-parallel circuits and case studies. Each topic consists of subtopics, summary, sample problems and a quiz.

To demonstrate the basic concepts of electricity, the module starts with a simple electric circuit that consists of a voltage source, a variable resistor, a light bulb and a switch. As the student clicks on the switch to close it, the electric current flows in the circuit which
in turn turns the light on. This animation shows the relationship between closing the switch, current flow and light. Also, it will show the effect of the value of the variable resistor on the current flow and the light intensity.

In the development of each subtopic, an introduction and explanation of the relevant terms and basic concepts are first provided in an interactive form. Then, a set of sample problems are worked out where the solution techniques are emphasized. Once a topic is covered, an exercise is presented and the student follows the solution techniques presented earlier to solve the exercise problem. In each step of the solution, the student must supply the correct answer before he can proceed to the next step of the solution. If the student cannot reach the proper answer in three attempts, then the student is forced to go back and review the material again before proceeding further.

Once the student successfully gets through the exercise, then he is ready to take the quiz and to conclude the topic. The quiz follows the same format as the exercise and again emphasize the solution techniques. The student is continuously presented with multiple choices at each step but have unlimited time to come to the true answer. Help messages and online hints are available and the student can call and refer to them. Every topic uses animation to demonstrate and simplify the concepts.

**Objectives of the Curriculum**

The objective is to develop competencies in the Principles of Electrical Engineering knowledge area including physics. It is designed to provide candidates (students) with enough background that is relevant to the manufacturing environment at Focus:Hope. Also, have the depth that will be very useful to support/supplement the educational efforts at the participating universities in this field. In appropriate modules, candidates will first locate and identify an actual Electrical Engineering System that will be subsequently modeled by an appropriate circuit model. Then later will be undertaken after the students are exposed to the fundamental concepts of Circuit Analysis techniques.

In this paper we will discuss the difficulties and the challenges associated with using CBI to replace some aspects of traditional classroom learning. The Greenfield Coalition is a National Science Foundation supported partnership of six diverse educational institutions, five top manufacturing companies, an international member-based educational society, and an operational manufacturing/teaching enterprise.

**The Greenfield Coalition**

The coalition’s vision is to create a world-class manufacturing engineer and engineering technologist highly sought by industry. The mission of Greenfield is to educate a proactive manufacturing engineer and engineering technologist who seeks, integrates, and applies deep knowledge to create and implement innovative product realization processes which provide global opportunities and competitive advantage for the manufacturing enterprise.

Preparing these ‘renaissance’ technologists and engineers requires next-generation courseware designed to integrate training issues with educational foundations. Intra-university Coalition development teams are designing and producing these learning programs using innovative educational approaches and advanced information delivery techniques. The outcome: a new ‘transportable’ curriculum specifically designed to facilitate industry/academic partnering, while instilling a balance of knowledge, skills, values, and behavior. This ‘vision’ infers a number of important competencies in areas such as:

- leadership and teamwork
- ability to seek, understand and apply knowledge from a variety of traditional disciplines
- deep phenomenological understanding of products, processes and systems necessary to push the envelope of design and practice, and
- broad understanding of the entire enterprise, including the impact of technological decisions on profits, society and the environment.

This curriculum is first being executed in an operational manufacturing enterprise (Focus:Hope’s Center for Advanced Technologies), and then transferred with minimal alteration to legacy university programs. As such, Greenfield is a new model for manufacturing education that focuses on the changing patterns in industry demands, previously underutilized sources of engineering/technology graduates, and innovative pedagogy.

The six university partners of the coalition will, in effect, become a virtual university, each developing and delivering modules for the candidates at the CAT. As the modules are aggregated into courses, and then into programs, three university partners will confer the
undergraduate degrees: Lawrence Technological University (Associate’s Degree), Wayne State University (Bachelor’s Degree in Engineering Technology) and the University of Detroit Mercy (Bachelor’s Degree in Engineering).

The new model for advanced manufacturing education is being demonstrated at the Center for Advanced Technologies (CAT). The CAT is a part of Focus:Hope, a human civil rights organization started over 25 years ago. A futuristic, 220,000 square foot facility has been reconstructed from a former Ford factory to create a radically different manufacturing/learning enterprise. The CAT is equipped with $55 M in leading edge manufacturing and information system equipment. The ‘candidates’ (students) in the CAT are employed within manufacturing contracts from the automotive, aerospace and durable goods industries.

The Development Tools

A good CBI development tool should have pre-programmed elements for interactive multimedia developments. Such tool enables combination of on-screen text and images with digitized sound, voice, photographs, and motion video-in-a-window [6]. It is a programming tool which takes less time to program than high level language programming (1/8 th). There are variety of authoring paradigms (metaphors) which vary widely in capabilities, orientations, and learning curve [7, 8]. For example, Scripting paradigm is a powerful object-oriented scripting language. You may need to specify the filenames of multimedia elements, sequencing, hot points, etc. Therefore, it is considered an authoring tool which is the closest to high level programming language.

Hypertext Markup Language (HTML) is a good example of such paradigm. Another interesting paradigm is the Iconic/Flow control paradigm which is require the least development time. Such metaphor is best suited for short-development time projects. It contains Flow Line, which shows the links between elements, and Icons, which may represent different functions and interactions of a high level program.

Authorware is an excellent example of such paradigm. There are other paradigms such as Frame, Card/Scripting, Cast/Score/Scripting, Hierarchical Object, and Hypermedia Linkage paradigms. What is the best authoring tool? It depends on the applications and developers.

Since the developers of Greenfield Coalition are Faculty from different schools with various programming backgrounds, we decided to use Authorware Professional which is an Iconic/Flow Control paradigm [9].

Macromedia’s Authorware Professional has been selected for the following reasons:

1. It was icon-based (various developers let it be known that they did not want to have to learn a programming language in order to develop CBI modules.

2. It was cross-platform at the PC level even though the widely-available version 2.0 can only translate from Mac to PC, and not the other way (however, version 3.0 will go both ways).

3. A developed module can be capsulated, shipped and run as an executable without the development application.

4. Run times are free meaning there is no royalty fee for distribution of executables.

5. It had widely available training and support, and

6. It had a large user base, with a substantial academic representation.

Developers with experience in programming indicated that Authorware was easy to use but felt limited by the lack of a scripting language that would allow further extensibility. However, developers with little or no programming experience reacted differently. It took them a fairly long time to adapt to the tool. They were grateful for lack of scripting language, but as it required a steep learning curve as well as the re-thinking of their course structure and contents, it has taken more time than originally anticipated to produce quality CBI modules.

We are currently delivering the module to Focus:Hope candidates. The students took the developed CBI module in the first week. In the second week, they read the selected reading from a selected text book and other references. Then, they will try to do their homework. A graduate student is with students during their class time. The instructor will meet with students in the third week to answer some of the difficulties questions. The written test will be completed in the fourth week. Overall student grades will be combination of on-line testing, case study report and written exam.
Student evaluations will be conducted after each module to improve the future module offering.

**Conclusions**

A module for the electric circuit elements and laws, which is the second module in Electro-physics Curriculum, has been developed as a Computer Based Instruction. Authorware Professional 2.0 has been used as the Authoring tool. Version 2.0 has some limitations. Most of these limitations were enhanced in version 3.0. CBI can offer an extremely efficient and cost-effective approach for both instructional development and delivery.

Although up front development time/cost is high, delivery economies include a single message deliverable in multiple and customizable ways, thus allowing minimal interruption of work schedules for both students as well as employee training, and eliminating or greatly reducing the need to travel to school or training center sites. But perhaps most importantly, it gives instructors the ability to develop encapsulated elements of their courses off line, that is, in their offices instead of traveling to different sites and repeating the same information.

**References**


**Nizar Al-Holou, Ph.D.**

Nizar Al-Holou is an Associate Professor in Electrical Engineering at the University of Detroit Mercy, Detroit, Michigan.

**Mahmoud A. Abdallah, Ph.D., P.E.**

Mahmoud A. Abdallah is an associate professor in the Manufacturing Engineering Department, Central State University, Wilberforce, Ohio.

**Acknowledgment**

The work based upon work supported by National Science Foundation through Greenfield Coalition (Grant #EEC‐9221542). The Authors would like to acknowledge Mr. Nader Demiri, the programmer, and thank him for working on this project.