

Learning in a Computer Classroom with an Interactive Book

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Abstract

An introduction to digital signal processing is being taught with an interactive book in a computer classroom. The interactive book is a set of Mathcad documents bound with hyperlinks and with navigation, full text search, and annotation facilities. The documents consist of interactive text, graphics and mathematics. The computer classroom has twenty student PC workstations, forty seats and an instructor's podium with PC workstation, lighting and projection (computer screen, overhead, and video) controls. The electronic book, computer classroom, learning methods and student evaluations over three semesters will be discussed.

Introduction

An appreciable part of science and engineering is concerned with mathematical models. The creation of mathematical models directly in a high level mathematical computer language unites modeling with simulation [1]. Such languages and model/simulations are particularly useful in the early stages of a development cycle in engineering practice. They afford, e.g., economical trial-and-error solution and graphic visualization [2], two powerful learning methods.

It is natural to teach engineering in the same environment, thereby taking advantage of the same powerful learning tools. By relegating unedifying and infeasible computation to the computer, the learning activity is raised to a higher conceptual level [3,4]. Of course, as computers are pervasive in all aspects of engineering practice, it is sensible to place educational activity in the same context, to a significant extent. Additionally, an emerging trend in engineering education is to bring theory and practice somewhat closer; making the graduate more employable but also providing often needed motivation.

Interactive Book

The choice of a high level mathematical language involves the consideration of a number of attributes. Mathcad [5] was chosen because of its superlative interface, low learning threshold, very

reasonable cost (\$80) and its facility to do all required operations at the appropriate level of complexity. It also has excellent communication features- e.g., a built-in web browser, easy document linking- locally and on the Web, and easy animation- the creation and playback of AVI files.

Mathcad documents consist of text, graphical and mathematical regions, all interactive and editable by the user. The mathematical facilities include numerical and symbolic mathematics and many built-in functions such as, importantly for present purposes, fast Fourier transforms and optimization algorithms. The latest version has an elegant programming capability. It is a popular mathematical application with more than one half million registered users. It has been used in education [6] and would seem to be ideal for wider use.

While an interactive book may be bound using the built-in linking features of Mathcad, the Mathsoft Corp. supplied the author with an authoring kit that allowed a more elaborate binding, with navigation, full text search, annotation and special hyperlinks. The construction of such a book is within an individual's capability. With the built-in connections to Notes, e-mail and Web browsing, a distributed team effort is possible- as would be distributed learning. The annotation feature greatly reduces the need for traditional note-taking, with the original version always available. Special pasting, in addition to those of the operating system, assist students in constructing their own documents.

The book, with compressed files occupying one diskette, is made available on a file server for students to install in their own PCs- more than one half do so. Also, a hardcopy is made available by the University reprographic service at a very modest cost (\$15)- almost all buy it.

Computer Classroom

The computer classroom is a natural evolution of the traditional classroom [7]. It allows "learning-by-doing", a learning method that nearly doubles the effectiveness of "seeing and hearing" [8]. Unlike a teaching theater which requires a production staff, the

material preparation is within the capability of an individual. The new teaching mechanics required are relatively easily learned.

In combination with an interactive book, all the basic material is electronically delivered and little traditional note-taking is required. This removes a major impediment for some students. Additional materials, including projects worked out in class, in the form of Mathcad documents, are placed in the instructor's public account and are accessible by file transfer and also with the built-in browser in Mathcad. In fact, the set of documents are hyperlinked with Mathcad's linking facility.

Learning Methods

The interactive book and the computer classroom allow active student participation in the classroom. A typical class session may consist of a review of some aspects of a section, the joint working of exercises and examples- especially with "what if" computations- and the initiation of projects. Mentoring is done by the instructor, an assistant- a graduate of the course- and by the students themselves. The classroom atmosphere is more collegial, with the instructor participating in the work along with the students and/or doing individual and group mentoring.

The required material in the course has been reduced by one-third. Each student is asked to submit a self-paced and self-selected syllabus describing how he or she will augment the core; it may be revised as interest changes. The interactive book contains more than one hundred exercises, some of which may require consulting traditional texts, and several dozen projects. These are a primary source for work submitted.

The student's work is evaluated in two portfolios and a final project. A portfolio is a collection of work that documents the student's progress and accomplishments [9]; it is a set of student-created Mathcad documents. The final project, also a Mathcad document, is presented to the class in the computer classroom. A demonstrated competence in the core material merits an average grade (B) and evidence of creativity merits a higher one (A). (The average GPA of enrolled students is 3.3). The documents, being computer programs, are self-checking. They are submitted either on diskette or by file transfer. The latter is especially convenient because the instructor can access them with Mathcad's built-in Web browser. (For security, special write-only directories are also being used. An entirely satisfactory solution is being sought.)

The interactive book and the computer classroom seem to encourage group participation [10]- as does the recent requirements of many prospective employers. Self-selected groups are used, with a size of about four being encouraged. We have used various schemes: e.g., the portfolios can be individually produced and the final project may be done by groups. Generally these groups have performed very well with little or no guidance. We will consider a self-evaluation method by the groups in the future as well as some guidance material on how members are expected to participate and contribute.

While traditional office hours are maintained, with the interactive book running on a laptop driving a monitor, e-mail is more often used. Also, this last semester, the regular class periods, two per week, were supplemented by tutorial/working sessions, at first four then later two tutorial sessions per week. Mentoring by the instructor, the student assistant by among the students was used heavily in these extra periods.

Examples of student portfolios and final projects, project solutions and sample chapters of the interactive book can be found at <http://www.glue.umd.edu/~harger/rohmpg.mcd> , most easily with the built-in Web browser of Mathcad 6.0 or, e.g., with the latter installed as a helper application in Netscape. About two dozen screen shots from the interactive book and its use are included in [11].

Evaluation

The students are twice asked to formally evaluate the various aspects of the course, once after a few weeks and at the end. This is done with questionnaires containing several dozen items with three responses: negative, neutral, and positive. Comments are also sought.

The responses show a high level of approval of the learning scheme. A preponderant majority are positive about the mathematical language Mathcad, the interactive book, and the computer classroom and would again take such a course offering. The portfolio scheme and final project presentation are viewed very positively, being much preferred to traditional tests. The self-pacing and self-selection of course content is viewed positively, with a few uncomfortable initially with the idea. A large majority is positive about the scheme's accommodation of diverse learning styles. (The classes are very diverse

in many ways: gender, ethnicity, race, computer literacy, age, etc.)

The most often cited comment on the computer classroom is that one is interacting with the material being learned. The most often cited comment on the interactive book is that it allows instantaneous feedback in trial-and-error investigation. A large majority are pleased with the active and practical involvement in the subject. A few are

at first uncomfortable with the possibility of not acquiring sufficient "theory" but realize by the end of the course that they have learned the theory much better: in one instance, the individual served as a reference to allay such a worry in prospective students!

A traditionally-taught section is also offered and comparative comments could be sought. However, the mathematical software, the interactive book and the computer classroom allow an altogether different kind of course to be offered. It is on a higher conceptual level with an attendant change in content. E.g., entire systems may be modeled, simulated and studied, replacing the "toy" analytic problems amenable to a traditional course.

Summary

It is believed that the interactive book in combination with the computer classroom has integrated mathematical modeling and simulation and enabled a markedly more holistic treatment of the subject. This increases student motivation and gives them more marketable skills. Diverse learning styles are accommodated by enabling easy graphic visualization, trial-and-error solution while retaining traditional mathematical language, a reduced course core allowing more initial experimentation and a degree of self-pacing and self-selection in the course syllabus, and encouraging creativity with portfolios and final, integrative projects in place of traditional tests. With the lectures delivered electronically, student interactivity is paramount during class time. The more mentor-like role of the instructor contributes to a friendlier learning environment.

In any event, the combination of an interactive book and a computer classroom is regarded as a successful venture by the instructor and by almost all the students. Perhaps we all feel that we are "learning in the age of the inconceivable" [4]! The course now has a wait list!

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