# Teaching with an Interactive Book in a Computer Classroom

**Robert O. Harger**
**University of Maryland**

## Introduction

A significant part of engineering education and practice is concerned with the creation and analysis of mathematical models. Mathematical programming languages have evolved sufficiently to allow interactive model representation that enables relatively easy implementation, verification, analysis and simulation. Indeed, a model and its simulation can be synonymous. The conceptual level of a study is raised significantly when unedifying calculation is relegated to the software. The Mathcad programming language[2] has evolved to the point that it is possible to write an interactive book directly in that language for an introduction to digital signal processing.

The use of computers in engineering practice is pervasive and it desirable to reflect this in engineering education[4,5,6]. I have been using the interactive book in a computer classroom, a natural evolution of the traditional classroom. The combination of interactive book and computer classroom allows flexible experimentation with degrees of self-selection of course material, self-pacing and group activity; diverse backgrounds and learning styles may be better accommodated.

The interactive book, computer classroom, effective learning methods, student evaluations and future plans will be discussed.

## The Interactive Book

Embedding mathematical models directly in a fill-featured mathematical programming language unites the powerful learning tools of mathematical abstraction and symbolization with visualization and trial and error experimentation. There are perhaps a dozen attributes that one would evaluate in choosing a mathematical programming language for teaching purposes. I give weight to (1) an economical package so that students, the majority of whom have their own PC, can purchase it; (2) a low learning threshold, (3) an appropriate implementation level , (4) an adequate set of built-in functions including symbolic mathematics, (5) a familiar graphical interface with a self-documenting and reporting capability, and (6) a facility for binding, or linking, documents into an interactive book. Mathcad met these and other requirements: it is a very attractive, versatile

and economical application. While it claims a half million users, it maybe an unduly overlooked mathematical programming language, well suited to undergraduate engineering education[10].

Mathsoft, the publishers of Mathcad, made available an authoring kit with which to construct an interactive book for instructional use. The interactive book is a set of hyperlinked Mathcad documents, each of which consists of interactive regions of text, graphics and mathematics, both numeric and symbolic. The book has a navigational pallet, fill text search, special cut-and-paste to student-created documents, annotated copy maintenance, and several types of hyperlinks. The book installs easily and is accessed under a "Book" menu item in Mathcad running under Windows 3.1 or 95. It is made available on a file server at no cost and a hard copy is made available at a very modest cost. For a sampling of the book and related teaching material including student projects, the reader may see Harger[3] Access is easiest with Mathcad 6.0's built-in Web browser. Alternatively, Mathcad can be easily installed as a helper application in Netscape (with the type/subtype designation application/x-mathcad and extension mcd).

## The Computer Classroom

The computer classroom is a natural evolution of the traditional classroom that makes a reasonable demand for new teaching and learning skills. The computer classroom I used has twenty PCs for forty students, an instructor's podium with PC and control of computer screen and document projection. The space was designed for this use with built-in desks, carpeting and environmental control of temperature and lighting. The computer access allows students to "do" as well as "see and hear", a combination nearly twice as effective as the latter alone[6]. It engages students in a learning environment that is closer to the contemporary engineering environment. And it allows the intensive use of computer software, not only contemporary engineering software but also electronic learning materials such as interactive books. A communication suite on the file server includes email, telnet, file transfer, Internet access and Web browser.

## Teaching Methods

A theme in current engineering education is the introduction of teaching methods which are more in accord with current engineering practice and which better accommodate diverse backgrounds, motivations and learning styles. The interactive book and the computer classroom allow the student some freedom to modify the course content and pace and learning method. Each student is required to design a syllabus and schedule with topic selection beyond a required core. The reduction of the required core allows, first, a slower introduction with more initial experimentation for those requiring it and, second, student self-augmentation of course content according to their own interests. This latter feature is highly motivating, a crucial factor in learning[11]. Each student may then categorize a particular class session as "core", "selected interest" or "nice to know". Extra tutoring is made available in class and in extra sessions, especially in the early part of the course, to assist in mastering the learning technology.

The scheme facilitates a more collegial participation among the instructor, tutor and students. Atypical class session may review the related book material, work some of its exercises and initiate one of its projects. Students can maintain their own annotated copy of the book. Little note-taking is required and the black/white board is rarely used. Variable groups initiate larger projects in some class periods, working independently with mentoring from the instructor, the tutor and themselves. Tutors are selected from earlier graduates of the course, with diversity a consideration. The interactive book is the primary text, with traditional textbooks on digital signal processing placed on library reserve.

Student progress is evaluated with two or three portfolios and a final project, all comprised entirely of Mathcad documents. There are no traditional tests; letter grades are used and the evaluation stresses creativity. The portfolio contents are selected by the student from the exercises and projects in the book, supplemented according to his or her interest, to show effort, progress and achievement[12]. The final projects are presented in the computer classroom before the class. These typically involve modeling, design, and simulation. Projects have involved filter design (e.g., cross-over networks, quadrature mirror filters, model determination by least-squares/pseudo-inverse methods, filter bank equalizers), speech processing (e.g., determination of LPCs), image processing (e.g., motion blur removal, character recognition, Markov random field generation for textures), adaptive filtering, adaptive equalization, wireless voice communication, QAM communication with v34 protocols (accompanied by actual implementation on DSP chips in a contemporaneous laboratory course), and many others. The limitations of Mathcad for large data sets is sometimes encountered: but learning to fit the problem to the computer is a valuable professional skill. For many students, their project presentation is their first quasi-professional presentation and the relaxed atmosphere is helpful.

Communication outside of class is mainly by email. Traditional office hours are held, with the book running on a laptop computer with an auxiliary monitor. A nearly paperless class is attained with student work being submitted, as Mathcad documents, on diskettes or by file transfer.

## Evaluation

I have now taught introductory digital signal processing with the interactive book in the computer classroom for three semesters to about eighty students. Detailed questionnaires reveal that the computer classroom, the interactive book, Mathcad, the portfolio and project evaluation scheme, and the accommodation of diverse learning styles are very positively viewed by the students. Even group activity finds increased approval[13]. A majority of students report an increased interest in the DSP area after taking the course. My own evaluation fares relatively well, probably in part because of my necessarily greater involvement.

## Future Plans

The Department is planning a larger computer classroom, with 36 PCs, one per student, improved and versatile computer screen selection and projection. The facility will be used for a wide variety of undergraduate

courses, including digital signal processing, digital image processing, communication systems, control systems, "introduction to systems and analog and digital circuits. It will also be used to supplement traditional offerings. Also planned is the addition of UNIX servers and an X-Windows capability with more sophisticated software for advanced courses.

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**ROBERT O. HARGER** (Ph. D., U. of Michigan, 1961) teaches in the Electrical Engineering Department at the University of Maryland where he served as chair (1 975- 1980). He is a Life Fellow of the IEEE and received the 1977 Carlton Award of the IEEE AES Society. He is interested in teaching with technology, especially using mathematical software in a computer classroom.