Electronic Books as Teaching Supplements

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Abstract

The next wave of the computer revolution in Engineering education is the implementation of the electronic book as an important supplement to course materials. It can contain everything that a printed text contains, but it can also incorporate self-pasting problem statements, live worksheets, and multimedia elements. The electronic book is an editable document, allowing each student to incorporate his/her own notes from classroom discussion or self-study. Problem solutions can be provided at the click of a mouse, and these are also editable. Distribution can be as simple as a file drag and drop into a public server directory. Commercially available tools now make the creation of electronic documents as easy as using a word processor. The example that forms the basis of this presentation is a Mathcad electronic book that has been used for two years by students in a Freshman/Sophomore course on Material and Energy Balances. The document is described briefly, but the focus is on an instructor's investment in time and resources required to produce such items for classroom use.

Introduction

An electronic book is a document that is designed to be viewed on a computer screen. It exists only on a local network file server or a World Wide Web server, and is created with no explicit intent of ever being realized in printed form. It is a "book" in the sense that it addresses a significant portion of a subject area and consists of chapters with an associated table of contents and an index. This is a new medium, however and has characteristics that make it distinct from a printed text apart from its ephemeral electronic form. The electronic book is particularly suited to enhancing learning outside the classroom, and can significantly reduce the burden associated with computationally intensive course material. This paper is concerned with the use of electronic books as supplementary resources for students in engineering courses.

Characteristics

A distinguishing feature of the electronic book is extensive hyperlinking. The set of links created by an instructor permits a user to rapidly find definitions, concepts, equations, and related information. In this sense, the electronic document has more in common with a database than a printed text. The organization of these links is the most significant issue in the design of this genre of books. Page numbers and linear ordering have less relevance in this medium than they do in a standard text. Textual discussions are commonly "layered". That is, a summary of a topic is presented on a single page and details and extensions are accessed via the links.

Depending on the particular tool used to create the electronic book, multimedia elements can be embedded to enhance its pedagogical value. Carefully selected audio or video clips and animations aid in understanding dynamic subject matter. Some authoring tools permit a viewer to execute small applications or "shell out" to other environments, for example, to simulation packages, statistics packages, drawing tools, or equation solvers. These tools must be present on the same file server on which the electronic book resides.

The electronic book complements a printed text. Students perennially complain that texts provide too few examples, and these are seldom annotated with sufficiently detailed explanations. If an author supplied multiple examples for every concept, and explained each in full detail, the resulting printed text would be daunting both in cost and sheer weight. The electronic book has no size limitation. An author can provide an unlimited number of examples. The user is not overwhelmed by the size of a document because there is never more than a screenful of information in view. The ultimate size of the electronic book is hidden. The user only needs to know how to find what he/she needs. One student may study only one or two examples to achieve a desired level of confidence, while another may examine several.

Worked problems are fruitful candidates for a layered design. Explanations can be attached with hyperlinks to each portion of the solution developed for an example. Students in need of casual assistance can

find it with a mouse click. If a brief explanation is not sufficient, a student can be referred back to a more complete textual discussion of the topic. On the other hand, the student who already understands the material can concentrate on the core development of the problem solution without all the attached verbiage. Many students learn exclusively from the examples. An electronic book meets their needs more effectively than a printed text. If the environment in which the problem solutions are created supports machine computation, then the student can also experiment with different parameter values.

Electronic books may not be suitable replacements for printed texts because the computer screen imposes an ergonomic limitation. Most viewers cannot tolerate discussions requiring more than a screenful or two of text. Thus the electronic book is not an appropriate place to pursue lengthy, detailed textual explanation of a concept. However, this limitation has the benefit of encouraging brevity and sharpening focus. The electronic book is an excellent place to summarize the essential elements of a development pursued at length in a printed text. It encourages authors to focus on relevant issues and to avoid the goal of a printed text to be all-inclusive.

Student Perspective

An electronic book is an editable textbook. A student can augment a personal copy of the text with his/her own class notes and print only the sections needed, and thus have an individualized study guide.

The electronic book can serve as an interactive solution manual. Sample problem statements and figures can be cut and pasted into a personal worksheet and students can access supplied hints or solutions as needed. The effectiveness of self-study is particularly enhanced if an instructor designs an appropriate set of links to needed definitions and concepts. A feature that is particularly well-received by students is the issue of supplying required property data with a clickable link.

Teacher Perspective

Modern authoring tools make the creation of electronic books as easy as word processing. Creating links to figures, tables, or spreadsheets, inserting images or sounds, and the assigning of actions to screen elements such as underlined text or bitmaps is typically accomplished by merely filling in some dialog box. An instructor does have to be a Windows API expert to implement these features.

A finished book can be distributed to one student or a hundred students for the same cost. If files are maintained on a web site, updates can be made and distributed worldwide with the ease of drag and drop. All those worked solutions that formerly resided in an instructor's file drawer can now be made available to a large audience with relatively little cost in either time or funds. If files are maintained on a web server, then any updates one may wish to make are immediately available. Distributing lists of errata is a practice that can thankfully be relegated to history.

Impact in the Classroom

An experienced instructor is familiar with the roadblocks to learning the subject matter in a course and has probably coached several students through those obstacles. The electronic book is a convenient place to archive all that acquired experience.

If the electronic book is used to supply a number of carefully selected worked examples, students tend to master concepts more quickly. The availability of on-line help for each sample problem makes self-study more effective, so that students are able to grasp material at least well enough to come to class prepared to ask relevant questions.

Computational Environment

The demise of programming language instruction has coincided with the advent of high-level computational tools such as Mathcad, Matlab, Maple, and Mathematica. With these tools, students can accomplish in minutes what formerly required hours of programming and debugging. In our department students learn to use Mathcad as freshmen and use it almost exclusively for every course requiring any sort of computation. Using only Mathcad, it is possible for students to produce high-quality homework documents with text, equations, figures and plots seamlessly integrated.

Creating an electronic book *within* the environment of such computational tools is well-suited to engineering courses. The computational engine with its associated equation solvers and matrix manipulation features is immediately available. In such an environment, the electronic book is "alive" not only with multimedia elements, but the equations embedded within it are also evaluated.

The authoring version of Mathcad, obtainable at no charge directly from Mathsoft at URL http://www.mathsoft.com/ was used to create an electronic book for a two-semester Material and Energy

Balances course. The authoring version of Mathcad differs from the standard version only in one respect. The Edit menu is augmented by a selection which allows an author to attach "actions" to various screen elements. An action can include automatic cut & paste of an entire problem statement, figure, and data into the student's worksheet, but most often it is simply a selection of a link to another part of the document.

The electronic book becomes part of the native Mathcad environment when files are placed in an appropriate directory. That is, the book under discussion can be selected from a menu and is thus as readily available as all the other Mathcad tools. Students can be working on their own documents and still have convenient access to the book supplement. In a sense, including an electronic book tailors Mathcad for use with a specific course.

A Specific Example

Since the Mathcad environment is used heavily by our students, an electronic book on Material & Energy Balances specifically tailored for this environment was written. Portions of the book have been used for two years. The first part of the course is taught in the spring of the Freshman year. Students typically enter the course already Mathcad-literate. Those students who are not familiar with Mathcad require only a couple class demonstrations to become skilled in its use.

Book Organization

The Material and Energy Balances course deals with the analysis of complex chemical process flow sheets. We currently use a standard text by Reklaitis [1]. An electronic book was created which is organized in chapters roughly corresponding to those in Reklaitis. Each chapter begins with a summary of definitions and applicable principles, and is followed by a series of focused examples. There is also a heavily cross-referenced index.

The first section in each chapter is a brief summary of principles and definitions. The objective is to supply enough background material that recourse to the printed text is not necessary while working problems. Detailed proofs or justifications are left to the printed text. The electronic book contains all the working equations and concepts needed to analyze chemical process flow sheets.

Examples typically consist of a problem statement, a schematic drawing and a large amount of data. All this information, including the drawing, can be pasted to the student's worksheet with two mouse clicks. Detailed analyses follow each problem but are not immediately visible. These are available, however, with a mouse click.

The electronic book has been used as a supplement to the printed text. Typically, a mix of problems was assigned from both sources. Examples from the electronic book were assigned as a study aide along with additional problems from the printed text for which no solutions were available.

Results

This strategy appears to be effective. Students using the electronic book were measurably more skilled at flow sheet analysis than students from previous semesters when the electronic book was not available. Student comments indicated that they learned more from the summaries in the electronic book than from the printed text. However, they also indicated that they needed a printed text as a resource. They did not think that an electronic book alone was adequate. The preference for a "hard copy" to study is persistent and strongly entrenched.

This Is Easy to Do

Anyone already familiar with Mathcad as a computational tool can learn to use the authoring tools in one afternoon. Any teacher who has already accumulated a number of worked examples (in Mathcad) for any course can easily put them into an electronic book. The discipline of adopting a consistent style is all that is required.

References

1. Reklaitis, G.V. "Introduction to Material and Energy Balances", Wiley, 1983.