

FINITE MATH ON THE WEB –
CORE MATHEMATICS DELIVERED VIA THE WEB

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Abstract: Finite Mathematics is one of the main components of the core mathematics curriculum at many colleges and universities. Although the graphing calculator is usually an integral part of the course, there are many concepts (such as set theory and the simplex method) that are both visual in nature, as well as highly interactive, yet not easy to adapt to a graphing calculator.

The authors have identified 10 fundamental areas in the standard Finite Math curriculum and have developed interactive web modules for each of them. They are:

- Lines and Slopes,
- Least Squares and Regression,
- Matrices and Systems of Linear Equations,
- Linear Programming (the Method of Corners and the Simplex Method),
- Sets,
- Counting and Probability,
- Conditional Probability,
- Statistics,
- Probability Distributions, and
- Finance

Each of the modules begins with an introduction to the topic, examples, interactive exercises (usually developed around a key Java applet), and ends with a practice quiz. Through the use of a web-based assessment tool, an algorithmic graded quiz may be assigned to the students for each module. In addition, there is a print supplement containing additional explanation as well as detailed solutions and a multimedia CD.

This format is quite flexible, and very modular. It allows a student to focus on a topic in a way that is not tied to a particular textbook. Furthermore, it allows additional materials to be added quite easily - we are in the process of adding 10 additional modules in the area of Applied Calculus.

One of the advantages of the web-based delivery format is that students do not need to attend a computer lab. The modules have been designed to be accessed through modem-speed internet connections using most recent browsers and operating systems.

An overview of the project can be found at <http://www.finitemathtutor.com/>

Background and History of the Project: The *Finite Math on the Web* project grew out of the development of Java Applets for an honors Finite Math course in 1997-1998. Specifically, a Java calculator, and prototype Least Squares, Set Theory, and Probability applets were developed. The student response was very favorable and led to the implementation of several important design elements. A web site incorporating mathematical instruction as well as the java applets was developed from these courses. We realized very quickly that the number of applets needed to cover the fundamental content of the course was actually quite small, and furthermore, the combination of instruction and interactive applets was independent of the particular textbook used.

We then approached a commercial publishing company (Brooks/Cole) with the idea of developing a courseware package that could be used with any standard finite mathematics textbook. Initially the idea was focused on the creation of a web site, with a small number of exercises, and a brief (100 page) manual explaining the use of the applets along with some mathematical explorations based on the applets. The 10 modules mentioned in the Abstract derive from the initial set of applets developed for the project. Each module is centered on one or two interactive java applets.

We quickly realized that static exercises were not sufficient when the modules were used for more than one semester. The publishers also realized that there was not a good revenue mechanism for access and delivery of courseware material. For these and other reasons, it was decided to incorporate the Finite Math courseware into an assessment tool which was simultaneously being developed by Brooks Cole, called *Brooks Cole Assessment* or *BCA* for short.

The print manual grew into a 250 page supplement with additional exercises, solutions and multimedia CD. A dedicated website (<http://www.finitemathtutor.com/>) was created to make it easy to access, evaluate and review *Finite Math on the Web*. The final courseware package consists of:

1. 250 page book containing additional exercises, instructional material and answers to both the odd exercise problems and the sample quizzes.
2. Multimedia CD containing detailed solutions (full color PDF files), as well as sample applets and videos describing their use.
3. A companion web site <http://www.finitemathtutor.com/> which is publicly accessible.
4. Courseware/Assessment website at <http://bca.brookscole.com/> which is accessed with a PIN code.

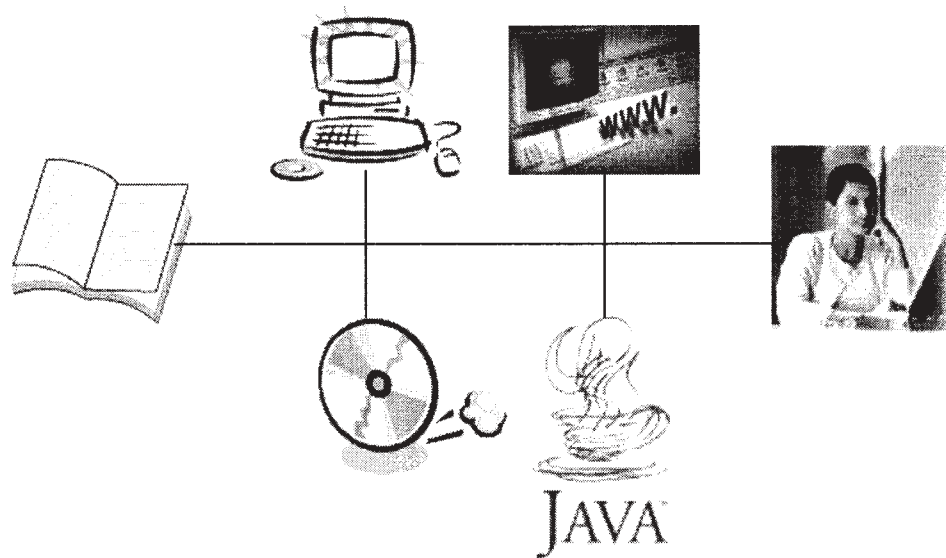


Figure 1 Beginning with a traditional textbook, we added the benefits of personal computers with multimedia. With the availability of the Web and Java applets, increased interactivity is possible. Finally, the assessment component was included for a complete courseware package.

Academic Setting: The Department of mathematics teaches over 5000 students annually in Finite Math and Business Math. These courses are part of the “Core Mathematics” sequence which students in Liberal Arts and Business are expected to take. Class sizes range from 80 to 100 students. There are three hours a week of lecture, and no recitations or laboratories.

Prior to this project, the main use of technology in the classroom was the graphing calculator. During the first few semesters, while content and applets were being developed, only a few classes used the courseware. In 2002, the decision was made to use it for all Finite Math courses, and in 2003 for all Finite Math and Business Math courses. Although there were problems, the system was remarkably robust. To help compensate for the different computer skills of students in Finite Math, a computer lab is open five nights a week to provide live help with the computer modules.

The main goal of the *Finite Math on the Web* project was to develop a courseware package that could be used by students with little or no technology background, no supervision, and using low bandwidth (56K modem) internet connections. For the most part, we feel we have succeeded, and would like to share our experience with others.

Courseware Components: As previously described, the *Finite Math on the Web* courseware package is comprised of a printed text, a multimedia CD and companion websites. While this is a fairly standard arrangement of material, there are aspects of the inter-relationship between these components that is worth mentioning.

- Since the students purchase the book before accessing the website, and often view a CD before even reading a single page of text, we put an auto-play flash movie which is run when the CD is inserted into the PC. This gives a student an overview of the product, as well as useful information regarding navigation and interacting with the applets within the courseware.
- The courseware assessment site contains graded material which is required for the course. This forces the student to use the PIN code (contained in the book) to log into the website. In order to prevent students from immediately going to the graded quizzes (bypassing all the instructional content!) the assessments are electronically assigned and collected during a small window of time. Unfortunately, students will tend to put off required assignments and will try to take the quizzes without reading preparatory material.
- The book contains answers to the odd exercises, but complete solutions (in the form of full color PDF files) are given in the CD, which encourages students to explore the CD.

Description of Module Content: Each of the modules begins with an introduction to the topic, then gives several examples which are followed by interactive exercises (usually developed around a key Java applet) and ending with a practice quiz. Through the use of the BCA assessment tool, a graded quiz may be assigned to the students for each module. This format is retained for each module, keeping a certain level of consistency for the students.

The Java applets form the core, if you will, of the interactive part of the courseware. Each of the applets is designed to have as simple an interface as possible. When a student is first exposed to an applet, the functionality is usually given in terms of mouse-click and mouse-drag. As the student uses the applets in more complex situations, additional functionality (in terms of buttons and pull down menus) is added. Finally, by the time the applet is used in the graded quizzes, it is present in its complete form. The applets can be completely configured through the HTML `<param>` interface. This is also where we pre-load data and other parameters into the applets in specific questions or examples. When the data is randomly generated and passed through the HTML interface, it makes it possible for the applets to be embedded into parametrically generated questions. This is discussed more fully in the next section.

One of the major advantages of the BCA courseware is its ability to render mathematics on the fly, as well as generate randomly generated parametric questions. When combined with the interactive applets, one can pose (and grade!) questions of tremendous complexity. Since the applets can record the problem-solving processes of the student (down to the key-stroke level if needed) as well as elapsed time, rich diagnostic

information is available to the student and instructor. The applets can also perform grading functions (the courseware is shielded from this complexity) and can be responsible for recording scores, elapsed times, number of attempts, etc. into the internal databases. This gives the project an enormous amount of flexibility and extensibility.

The navigation within the web site is fairly intuitive. The web pages are usually composed of a left frame and a right frame. The instructional material, examples, and questions are posed in the left frame. Applets, dialogs, scores and other grade related information appear in the right frame. This preserves a “book-like” interface, while allowing an applet to remain in the right frame for several “left pages” or multiple graphics and tables can appear in the right frame for a single “left page.”

The fact that the print material can be taken anywhere (without the necessity of a computer), and the CD can be used without an internet connection, makes the students use the courseware components in an efficient and effective manner.

Summary: This project has been successful enough to be used by close to 10,000 students. A companion project *Applied Calculus on the Web* has begun, based on the understanding gained in the *Finite Math on the Web* project. Some lessons we learned are

- Although PIN's are very useful for enrolling students are setting up unique student records, students should never have to worry about more than one PIN.
- If PIN's expire (and ours expire after one year), they should be able to be purchased (electronically) on the web inexpensively. This gives used courseware books value.
- The instructor should never be expected to resolve students' technology related questions; there should be a tech support site for this purpose. This is part of what the student is paying for!
- Computer programmers should not be ultimate source of mathematical questions. Instructors and teachers have the subject mastery.
- Whenever possible, questions should be algorithmically generated and be immediately graded to give students maximum feedback in the shortest time.
- Computer based assessment must go beyond multiple-choice and fill in the blank questions and involve the student in multi-step reasoning.
- “Assessment informs instruction.” The only way to know whether a student understands material is to perform some kind of assessment. Although continuous (background) assessment would be ideal in an adaptive learning environment, it is clear that some form of assessment is needed to control the delivery of instructional material. When should the student move on to another topic? Only when they have demonstrated a level of subject mastery through some form of assessment.