

APPLICATIONS OF MATH SOFTWARE IN ENGINEERING COURSES

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Introduction

Commercial mathematical softwares provide effective means for presenting and employing mathematics in undergraduate engineering courses. Applications include lecture aid, demonstration, learning exercises, and evaluation of student learning. In engineering, the forms of those applications are problem solving, simulation, and design, all of which typically are well suited to mathematical software.

The author has employed mathematical software in engineering courses for eight years, initially as a lecture aid and, over the past four years, in active learning and productive work by students. The courses involve analyses of functions, including integration, differentiation and graphing, and formulation and simulation of mathematical models. Those activities are performed by students and instructor exclusively at computers using a commercial mathematical software and supported by on-line knowledgebases. Each complete analysis produces a document. Instructor documents and knowledgebases are distributed via a Web server. Student documents are transferred between student and instructor via e-mail attachment. The instructor evaluates student work at a computer in the mathematical software.

Use of computers and mathematical software in courses has significantly improved instruction and student learning. It has also extended the computer skills of students. This paper discusses, demonstrates, and characterizes the author's methods for using mathematical software in undergraduate engineering education.

Commercial Mathematical Software

Several mathematical softwares are available commercially for applications to engineering education; Mathcad¹, Mathematica², and Matlab³ are just three examples. In selecting a software, an instructor should at least consider capabilities for producing verbal text, passive mathematical text, and active mathematics as well as the range of mathematical operations provided.

A particular mathematical analysis (problem) performed in a mathematical software produces a document. The reading and understanding of the document are facilitated by narrative (verbal text) throughout. Any mathematical derivations in the document

should be passive mathematical texts; scalar, vector, and graphical results throughout the document have to be produced by active mathematics. Ranges of mathematical operations available in the three softwares mentioned above meet or exceed, requirements of undergraduate engineering courses. Therefore, the author selected Mathcad¹ based on its capabilities in verbal text, passive mathematical text, and active mathematics. The methods employed in its application may be realized with other available softwares.

Instructional experiences with commercial mathematical software has led the author to believe that undergraduate engineering education is better served by students learning and employing consistently in all analytical work a mathematical software rather than a standard programming language. To satisfy requirements of some employers, study of a programming language as a senior elective may remain appropriate.

Application in the Classroom

The initial application of Mathcad¹ in the classroom, commencing in 1993, was presentation of visual components of mathematical analyses in lectures. Previously presented via blackboard and overhead transparencies, they were newly produced in Mathcad¹ and presented via computer/projector. Obvious advantages were: ability to produce once, save, improve, and reuse a particular mathematical document; it was typed with legible characters and good spatial arrangement; it could calculate numerical results and produce clean, scaled, and legible graphs; and effects of changed parameters and even equations could be observed. Although prior production of analyses in Mathcad¹ was desirable and best, extemporaneous productions during classes could be attempted with success providing they were not long or complicated.

Supporting knowledgebases were created via word processing for verbal and mathematical texts and drawing software for process diagrams and illustrations with final conversion to Portable Document Format (Adobe Systems) for platform independence and proper Web transfer of mathematical content. Mathematical text generally was created via the equation editor within the word processor; it, therefore, was passive. Some more recent mathematical content has been created as hyperlinked Mathcad¹ files permitting active mathematics with its benefits. The author now is experimenting with creating more of the mathematical content of knowledgebases as linked, active Mathcad¹ entities.

The past four years have been committed to making the classroom an active learning experience. Classes for courses were conducted in a computer laboratory with students and the instructor sitting at networked computers. Students have observed the visual content of instructor presentations on their own computer monitors. Those presentations included overviews of the knowledgebase, demonstrations of major concepts, and examples of problem solving and simulation. The majority of class time was devoted to active learning in which students individually worked problems in Mathcad¹ as exercises with guidance and eventual solution and discussion by the

instructor. The knowledgebase always was available to them via the Web. At a computer equipped with Acrobat Reader⁴, the reader may explore the knowledgebase for a course on Biological Systems Analysis at the URL

<http://www.agen.ufl.edu/~smerage/ABE5643/Book/Bk00001.pdf>

and extensive information about that course in its home page at

<http://www.agen.ufl.edu/~smerage/ABE5643/Home.html>

During the mid nineties and earlier, students did problems in Biological Systems Analysis inside and outside the classroom via pencil and paper. Since application of the computer to active learning commenced four years ago, students have done all problems inside and outside the classroom via Mathcad. Extensive sets of problem statements and solutions have been created for Biological Systems Analysis. They may be electively used by the instructor as examples, learning exercises, and evaluators of student learning. Each statement and each solution is a distinct Mathcad¹ file accessible via the Web. Many problems contain process diagrams and/or other graphical entities that were prepared via drawing software and pasted into the Mathcad¹ file. The reader may examine all available problem statements via an Internet browser and Mathcad¹ by selecting links in the Index of Problems at URL

<http://www.agen.ufl.edu/~smerage/ABE5643/Problems/>

Solutions to many of those problems may be examined via a browser and Mathcad¹ by selecting links in the Index of Problem Solutions at

<http://www.agen.ufl.edu/~smerage/ABE5643/ProbSols/>

The knowledgebase, home page, and problems for a recent, new course, Quantification of Biological Processes, are under continuing development. They should be available for examination by the outside world at the end of 2002.

Application Outside the Classroom

Outside the classroom, students have used available problem statements and solutions as learning exercises. The author uses problems done outside class time as a primary evaluator of student learning, and, over the past four years, students have been required to do all problem solving in Mathcad. They have accessed assigned problem statements via the Web on a computer at home or in a university laboratory and have solved them in Mathcad. A student has sent a completed set of problem solutions, a set of Mathcad files, to the instructor via e-mail attachment for evaluation. While evaluating a solution file within Mathcad, the instructor has added checks, Xs, comments, and a grade. Resaved, a set of evaluated student solutions plus a grade report have been returned to the student via e-mail attachment. In courses where

quizzes and exams in the classroom are necessary, a similar procedure would work very well.

In Biological Systems Analysis, a term project producing an original mathematical model of a specific system is required; it is another activity outside the classroom. Over the past four years, students were required to formulate their mathematical models in Mathcad¹. Preparation via computer of the project report included drawing process diagrams and other graphics and word processing. Many students elected to do their entire reports in Mathcad¹, utilizing its capabilities for passive verbal and mathematical texts and active mathematics.

Conclusion

Over the past four years, progressive improvements in instructor delivery of the content of Biological Systems Analysis and student learning in that course have been observed with the utilization of commercial mathematical software as described above. Integration of mathematical software, an electronic knowledgebase, the Internet, e-mail, and electronic home page of course information has significantly improved the qualities of course materials and their presentation and of student learning of both concepts and skills. Similar results have been observed in initial, limited offerings of Quantification of Biological Processes.

Instructor delivery and student learning have become more active; learning has even been self-paced. Students generally have been quite positive about Mathcad¹, its capabilities, and using it for all mathematical analyses. Many students have continued at their own initiative to use Mathcad¹ in other courses and in projects.

Mathematical analyses produced by both students and instructor are tidy and efficient. The wide array of mathematical operations, functions, and graphic formats available in the software are more than adequate for undergraduate engineering education, and they permit a wider range of problems and more sophisticated analyses than otherwise possible. Calculations are performed quickly. Simulations, equation solving, parameter variation, and "what if" questions are readily pursued. All these capabilities and benefits are available in classical mathematical terms and without the necessity for student to use of programming language.

References

1. Mathcad. MathSoft Engineering & Education, Inc., 101 Main Street, Cambridge, MA 021421521. <http://www.mathsoft.com/>
2. Mathematica. Wolfram Research, Inc., 100 Trade Center Drive, Champaign, IL 61820. <http://www.wolfram.com/>
3. MatLab. The MathWorks, Inc., 3 Apple Hill Drive, Natick, MA 01760-2098. <http://www.mathworks.com/>

4. Acrobat Reader. Adobe Systems Inc., 345 Park Avenue, San Jose, CA 95110-2704. <http://www.adobe.com/>

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