

RESTRUCTURING CALCULUS III TO INTEGRATE *MAPLE* TECHNOLOGY IN THE TEACHING AND LEARNING PROCESS

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1. Introduction

Eastern Connecticut State University [ECSU] ¹

Eastern Connecticut State University is the state's public liberal arts university. As a predominantly undergraduate institution, Eastern develops outstanding students who integrate learning with expertise in their chosen fields of study for both civic and career success in a highly technological and rapidly changing world.

Eastern offers a wide range of undergraduate majors in the arts and sciences and professional studies, and selected graduate programs, encompassing interdisciplinary and integrated approaches to teaching and learning. The University strives to be a model community of learners of different ages from diverse cultural, racial and social backgrounds.

Technology

The computer algebra system [CAS], *Maple 9.5*, is required in the Calculus III course. Use of the assessment software, *Maple T.A.*, is planned for fall 2005.

Maple 9.5 Computer Algebra System ²

“[*Maple 9.5* is] the environment of choice for mathematical problem-solving, exploration, data visualization, and technical authoring”.

Maple 9.5 was purchased in spring 2004 with funds awarded through a FIPSE grant ³. It is an integral part of MAT 340, Calculus III. We note that the CAS *MapleV* was first introduced in the calculus sequence in 1993.

¹ http://www.easternct.edu/ecs/mission_state.htm

² <http://www.maplesoft.com/products/maple/education/index.shtml>

³ With [Marsha Davis, Pete Johnson, Kim Ward]

Maple T.A. Assessment Software⁴

"*Maple T.A.* automates many time-consuming elements of modern post-secondary mathematics education. Derived from the legendary Maple software, Maple T.A. offers a Web-based system for creating tests, assignments, and exercises, automatically assessing student responses and performance. From homework, drill, and practice to placement or gateway tests, Maple T.A. provides an efficient, cost-effective alternative to paper-based testing and assessment. And, unlike traditional assessment systems, Maple T.A. supports complex, free-form entry and intelligent evaluation of responses, making this system ideal for mathematics, science, or any course that requires mathematics".

Maple T.A. was purchased in spring 2004 with funds awarded through a FIPSE grant ⁵. *Maple T.A.* was used to create a pre-entry exam for Calculus II students which tested Calculus II Core Topics; it was implemented in fall 2004. *Maple T.A.* will be used to create a pre-entry exam for Calculus III students. The MAT 340 Pre-Entry Exam will test Calculus II Core Topics and its implementation is planned for fall 2005.

2. MAT 340: Calculus III

MAT 340 is currently a three-credit course which deals with vector and multidimensional calculus. Technology is an integral part of this course. The computer algebra system *Maple 9.5* is used. The text used is Multivariable Calculus, 3rd edition, written by Strauss, Bradley and Smith. This course is taught in the fall semester.

MAT 340 Core Topics

As Chair of the Calculus Committee, I, in conjunction with my committee members, authored minimalist core lists of basic topics for each of the courses in the three-course calculus sequence. The goal of these core lists is to provide a common base of materials presented to students. Once these core topics are addressed, professors are free to teach other course-related topics of interest, time-permitting.

The core topics list for Calculus III is divided into two parts. The first part deals with theory and applications. The second part deals with technology. Topics are:

Theory/Applications

1. Functions of two or more variables
 - a. Definition
 - b. Techniques for graphing $f(x, y)$
 - c. Zooming in on a point – approximated by plane

⁴ <http://www.maplesoft.com/mapleta/>

⁵ With [Marsha Davis, Pete Johnson, Kim Ward]

- d. Normal vector
- 2. Geometry
 - a. Vectors in \mathbb{R}^2 and \mathbb{R}^3
 - b. Operations on vectors (including dot product and cross product)
 - c. Planes in \mathbb{R}^3
- 3. Vector Functions
 - a. Definition
 - b. Differentiation and integration
- 4. Derivatives
 - a. Partial differentiation
 - b. Tangent planes, approximation of surface at a point
 - c. Chain rules
 - d. Gradient
- 5. Lagrange multipliers
- 6. Applications
 - a. Motion (including unit tangent and normal vectors)
 - b. Modeling planetary motion
 - c. Extrema

Technology: Maple 9.5

- 1. Familiarity with Maple 9.5 Help System/Example Pages/Packages
- 2. Basics:
 - a. Defining variables;
 - b. Defining functions.
- 3. Computer Algebra:
 - a. Polynomial manipulation;
 - b. Solving equations (symbolically, numerically).
- 4. Graphics:
 - a. Plot surfaces, planes;
 - b. Contour plots;
 - c. Local linearity;
 - d. Vectors.
- 5. Operations:
 - a. Vector;
 - b. Dot Product;
 - c. Cross Product;
 - d. Gradient;
 - e. Differentiation;
 - f. Integration;
- 6. Lagrange Multipliers

3. *MAT 340 Student Resources*

Summer 2003

In the summer 2003 I was the recipient of a modest Faculty Development Grant, *Summer Curriculum Development: A Proposal to Restructure Calculus III to Integrate the Computer Algebra System Maple8 Technology in the Teaching and Learning Process*.

Faculty Development Grant Outcomes

The following outcomes are a result of support from the 2003 Faculty Development Grant:

1. *Maple 8* proficiency.
2. *A Fundamental Maple 8 Tutorial Designed for Multivariable Calculus*.
3. Course reorganization of MAT 340 to incorporate *Maple 8* technology.

A Fundamental Maple 8 Tutorial Designed for Multivariable Calculus

A Fundamental Maple8 Tutorial Designed for Multivariable Calculus serves as a reference for assigned tasks and/or discovery on the part of the student. It contains both text and graphics. Screen capture of *Maple 8* worksheets appear throughout the tutorial and illustrate commands and procedures which are relevant to the course materials. It was distributed to all students on the first day of class and was referenced often during technology demonstrations and lectures.

Summer 2004

A Fundamental Maple 9.5 Tutorial Designed for Multivariable Calculus

The Department upgraded from *Maple 8* to *Maple 9.5* using funds awarded through the FIPSE grant referenced earlier. Without benefit of funding, *A Fundamental Maple 8 Tutorial Designed for Multivariable Calculus* was revised to incorporate the changes from *Maple 8* to *Maple 9.5*. This involved retesting every screen capture of *Maple 8* worksheets found in the first tutorial. *Maple 8* worksheets containing commands that are still viable using *Maple 9.5* are retained; the *Maple 8* worksheets that contained commands no longer viable in *Maple 9.5* are discarded and replaced by equivalent *Maple 9.5* worksheets. Additional material is added to the content of the *Maple 8 Tutorial*; this includes “Basic How To” commands and examples followed by a *Maple 9.5* summary listing of common commands. In all, the content increased from thirty-seven pages in the *Maple 8 Tutorial* to forty-six pages in the *Maple 9.5 Tutorial*.

4. *MAT 340*

Fall 2003

The fall 2003 Calculus III course was reorganized as follows:

At the first class meeting the *Maple8* reference booklet was distributed to students. A technology demonstration was given and the students were introduced to *Maple8* and the online “New User Tour”.

At the second class meeting additional *Maple8* technology was introduced via demonstration. Technology concepts were reinforced via “Practice *Maple8* Exercises” which were distributed to the students; these exercises were completed in a laboratory setting on an as-time-permits basis. A second set of Assigned *Maple8* Exercises was distributed with a one week due date.

At the third class meeting, a differentiation-integration review sheet was distributed to the students; they were to complete the problems using paper-and-pencil computation and to check their solutions using the CAS.

Lab groups were formed. Lab Projects were distributed and the lab groups were allowed time to complete them in lab sessions.

Additional *Maple 8* technology demonstrations took place throughout the semester. These technology demonstrations reinforced and illustrated the various mathematical principles in the discipline and also the applications of technology.

Fall 2004

MAT 340 Course Modification Proposal

A Course Modification Proposal to change MAT 340 from a three-credit course to a four-credit course is currently before the ECSU Curriculum Committee. It received the approval by the Department, the Chair and the Dean. The rationale for the proposed change is the need for additional time to satisfy the requirements of the course and to adequately implement the technology.

MAT 340 Course Format

The *Maple 9.5 Tutorial* was distributed to students at the first class meeting. During the first two weeks of the semester students are introduced to the *Maple 9.5 Online Help* via *Maple 9.5* demonstrations and student hands-on practice. *Maple 9.5 Practice Examples* were distributed to students to be completed outside of class. In due time solutions were sent electronically. As a means to assess student competency, a *Maple 9.5 Mastery Test* was administered and graded. Again, solutions were sent electronically. Lab groups were formed, four students per group. To date, Lab Project #1 has been distributed. Lab Projects #2 and #3 will be distributed in the future. *Maple 9.5 Lab Projects* are collaborative efforts. In addition to technology projects there are three-in-class exams and a cumulative final exam. The course grade is determined by grades earned for in-class exams and the technology projects.