A WEB-BASED (WEBCT) INTRODUCTORY COURSE IN DIFFERENTIAL AND INTEGRAL CALCULUS

Ann Robertson
Connecticut College
Box 5378, 270 Mohegan Avenue
New London, CT 06320
arob@conncoll.edu

Introduction to Calculus is a 100's level single semester course in calculus. Topics of differential and integral calculus covered are similar to that of the regular calculus sequence. However, emphasis is placed on key concepts and problem solving strategies. Students with strong backgrounds in mathematics or who intend to take additional courses in the calculus are advised to take the usual calculus sequence.

Why use WebCT for such a course? Why not simply create a standard web site? The best answer is that the product allows one to concentrate on curriculum development. The entire structure of the course web site is easily organized and edited.

Each summer ten members of the faculty participate in a two-week workshop on both curriculum development and the technology tools of Adobe's Acrobat, MacroMedia's DreamWeaver and WebCT. Each faculty participant is supported by an Information Technology specialist and a librarian. An initial kickoff session, held six weeks before the workshop begins, is devoted to assessing one's selected syllabus. With the Director of Instructional Technology, an initial meeting is led by two veteran WebCT faculty who have won numerous teaching awards.

Fortunately, the writer had taught the Introduction to Calculus course once in 2001 and had goals and objectives in place somewhat formulated on Bloom's Taxonomy of Educational Objectives [1](Knowledge, Comprehension, Application, Analysis, Synthesis and Evaluation) and a plan to reach students with various learning styles [multiple intelligences] described by Gardiner[2] (Kinesthetic, Interpersonal, Intrapersonal, Mathematical, Musical, Verbal, Spatial and Naturalistic.) A previous workshop had

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[1] Bloom, B.S. (Ed.), *Taxonomy of Educational Objectives: The Classification of Educational Goals*: Handbook I, Cognitive Domain. New York: Longmans, Green, 1956. A current site on "Learning Skills Program – Bloom's Taxonomy" may be accessed at Counseling Services - University of Victoria, (29 December 2003) < http://www.coun.uvic.ca/learn/program/hndouts/bloom.html>

[2] A current site on "How Technology Enhances Howard Gardiner's Eight Intelligences by Dee Dickinson may be accessed at New Horizons for Learning and America Tomorrow, Inc. Permission for excerpt granted to America Tomorrow, Inc. Page updated 11 May, 2000; (29 December 2003) <http://www.america-tomorrow.com/ati/nhl80402.htm>

described the Myers-Briggs Type Inventory[3] and a description of "personality" types that suggested how students learn and work best. Objectives were derived in part from NCTM (National Council of Teachers of Mathematics) Standards for Reform Calculus.

Fortuitously, on the morning of the initial session the writer was paired with a Chinese professor. Commonalities soon became apparent. What was a symbol? What was a number? What exactly was the "language of mathematics" that students needed to learn? Having six weeks before the actual workshop allowed time for reflection and revision. The goals and objectives were fined tuned then and continue to be today.

The course design would not only focus on the student's understanding of key concepts and solution of problems but would also highlight the personalities and applications that brought the calculus into existence. Illustration of current real-life applications would convince the student of the importance of calculus and its value in a liberal arts education. Real life data would be "messy." Here was a great opportunity for students to evaluate data gathered for a given application critically. Equations would not be the usual neat ones presented in textbooks. The intention would be to raise the student's awareness of real life situations and to heighten the student's confidence in using ingenuity, common sense, and basic skills including approximation. Technology would be used as a teaching and reference tool; animations would be obtained from the Internet. The use of logical, graphical, numerical and analytical solutions would be compared when applicable. A Mathematica lab illustrating Newton's Method with an example used by Newton himself[4] and one exhibiting chaotic behavior [5] would support the historical and the current context of the course. Hopefully, students would be convinced that calculus was one of the greatest intellectual achievements and would develop an appreciation of the intrinsic beauty and elegance present in the subject. Further, students would be assisted in comparing and discriminating between approaches to solve problems and in communicating solutions with well-reasoned mathematical conclusions. The many resources of the course would clearly need to be delineated on its web site. What follows describes both details of the course and its accompanying web pages.

Textbooks for the Fall 2003 semester course included: *Calculus Lite*, Third Edition; Frank Morgan; A. K. Peters, Ltd.; Natick, Massachusetts; 2001 (required) and B*rief Applied Calculus*, Third Edition; Berresford / Rockett; Houghton Mifflin; Boston; 2004 (optional). Students could use a graphing calculator and a computer algebra system would be introduced.

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[3] A current site on "GSU Master Teacher Program: On Learning Styles" by Harvey J. Brightman, Georgia State University may be accessed (29 December 2003) at <http://www.gsu.edu/~dschjb/wwwmbti.html>

[4] Stewart, James, *Single Variable Calculus, Early Transcendentals*, Fourth Edition. Pacific Grove, CA: Brooks/Cole Publishing Company, 1999, page 347. Newton used $f(x) = x^3 - 2x - 5$ with $x_0 = 2$.

[5] *Learning By Discovery*, MAA (Mathematical Association of America) Notes, Number 27, pg. 49.

The following "Background Information" would be kept in the syllabus:

- Calculus evolved from four major problems that were pressing concerns in the seventeenth century. (1) Finding instantaneous velocity (velocity at a given instant of time) (2) defining tangent lines to curves (3) finding maximum and minimum values of a function and (4) calculating special areas and volumes. [6] [7]
- Sir Isaac Newton (1642-1727) and Baron Gottfried Wilhelm Leibniz (1646-1716) built upon the works of Eudoxus, Archimedes, Fermat, Barrow (Newton's teacher) and others. Both men had strikingly different personalities and lives; historical evidence shows that they worked independently of each other. [8] Yet great controversy resulted and members of the Royal Society in England accused Leibniz of plagiarism.[9]
- The two main branches of calculus are Differentiation and Integration; they are inversely related to each other. "What Newton and Leibniz did was to use this relationship, in the form of the Fundamental Theorem of Calculus, in order to develop calculus into a systematic mathematical discipline. It is in this sense that Newton and Leibniz are credited with the invention [discovery] of calculus." [10]

Most initial project ideas came from *Brief Applied Calculus*, Third Edition by Berresford / Rockett:

- Rate of change of epidemics: AIDS
- Absolute Zero and the Bosé Einstein Condensation *
- Growth rate of an oil slick
- Global warming
- The cost of safe drinking water *
- Maximizing profit
- Current research on soap bubbles **
- Fractal Geometry / Chaos * and ***
- Chaos and sensitive dependence on initial conditions *
- Continuous compounding of interest and e *** / *
- Carbon 14 dating

*Covered in class or lab ** Covered in primary text *** Covered by a student project

Before the "Limits Approaching Absolute Zero" class discussion and presentation, students were instructed to use the web to research Absolute Zero and Superconductivity and summarize each topic. A general source was given: http://www.colorado.edu/physics/2000/bec/temperature.html

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[6] Berresford/Rockett, *Brief Applied Calculus*. Boston, MA: Houghton Mifflin, 2000, pages 98 - 99.

[7] Kline, Morris, *Mathematical Thought from Ancient to Modern Times*. Oxford University Press, 1972

[8] Morgan, Frank, *Calculus Lite*, Third Edition. Natick, MA: A. K. Peters Ltd., 2001, pp. xi - xiii

[9] Page 1685 of Reference (4).

[10] Pages 409 -10 of Reference (4)

[...describes the work of Cornell and Wiemann] and a source for applications of superconductivity: http://www.conectus.org/xxsuperc.html. [Conectus is the Consortium of European Companies Determined to Use Conductivity.]

The class presentation on "The Cost of Safe Drinking Water" led to a detailed discussion on current legislation by the Environmental Protection Agency (EPA) and detailed data and equations used by the State of Connecticut. Students were again instructed to write a summary on some aspect of "The Safe Drinking Water Act" that was of interest before the class presentation on the cost of cleaner drinking water in 2001-- 2005 and how it relates to calculus.

Technology used in the course beyond WebCT included the academic courseware server, "drop" boxes, software including Mathematica, links, animations and a video clip.

Useful Internet sites included:

- "Why Calculus" Helmer Aslaksen, Department of Mathematics, University of Singapore http://www.math.nus.edu.sg/aslaksen/teaching/calculus.shtml
- "A History of Calculus", J.J.O'Connor and E.F. Robertson, School of Mathematics and Statistics, University of St. Andrews, Scotland http://www-groups.dcs.st-and.ac.uk/~history/HistTopics/The_rise_of_calculus.html
- "calculus.org: The Calculus Page", Department of Mathematics, UC Davis, The Morgan Foundation, and Department of Mathematics, Williams College, http://www.math.ucdavis.edu/~calculus/
- "Graphics for the Calculus Classroom", Douglas N. Arnold, http://www.ima.umn.edu/~arnold/graphics.html
- "MATH 226: Calculus", Edward Goetz, San Francisco State University, http://math.sfsu.edu/goetz/Teaching/math226s01/

Animations used included:

- Secant Lines Converging to a Tangent Line
- Functions and their First and Second Derivatives
- Continuity and the Functions $f(x) = \sin 1/x$ and $f(x) = x \sin(1/x)$, $f(0) = 0$
- Riemannian Integration

(All of the above were created by Edward Goetz of San Francisco State University under an NSF grant. This most valuable url: http://math.sfsu.edu/goetz/Teaching/math226s01.)

- Root finding using Newton's Method (See below.)

The lab portion of the course had the following supporting materials:

- Mathematica Primer
- Animation: http://math.furman.edu/~dcs/java/newton.html
- Newton's Method Lab
- Fractal Geometry (PowerPoint) and Characteristics of Chaos (PowerPoint)
- Clip from *Chaos: A New Science*

(Of enormous importance was the Fractal Geometry and Chaos web site created by Michael Frame of Yale University: http://classes.yale.edu/Fractals/ written under an NSF grant with Nial Neger and Benoit Mandelbrot.)

Information Literacy Tools / Links were provided for the student with very considerable assistance of a librarian (liaison to the math department.) The writer has found that many of the resources listed below were invaluable to students electing to do research papers or extra credit assignments.

- **Assistance with Research:**

Evaluating Web Sites, Subject & Research Guides, Personalized Research Sessions, ReferenceNOW, Library Hours, Library Catalog and Databases Grouped by Discipline.

- **Assistance with Writing:**

Citation Guides for Print and Electronic Resources, The Writing Center, Technology Instruction Schedule and Microsoft Word Tutorial

- **Assistance with Presentations:**

PowerPoint Tutorial and Photoshop Tutorial (future)
Technology Instruction Schedule

- Links were also provided for the student to download PowerPoint Viewer, Acrobat Reader and Quicktime Player.

WebCT Features that Worked Well:

- Managing and editing of all files, course information and student / guest accounts
- Setting up temporary and conditional files—This is especially useful for midsemester and final reviews.
- Creating montages for banners on a given page
- Changing the position of icons on the homepage as the semester progresses

WebCT Features that Did Not Work Well:

- The syllabus feature was restricting; uploading an html file worked well.
- Using the calendar feature for an assignment sheet (27 written assignments) did not allow for "on the spot" changes. Instead, a table was uploaded.

Future Uses of WebCT under Consideration:

- Using the class email facility, which many have reported to be safe from viruses
- Using its "Chat" facility for live "threaded" discussions for pre-assignments on the applications portion of the course -- Instructors using this feature report on students being better prepared for class discussions.
- Perhaps establishing "drop" boxes within the site itself rather than using a separate academic server and investigating the "Useful Resources on Plagiarism" link.
- Trying on-line quizzes -- While on-line grading has appeal to some instructors, the ability to assess student work and to provide feedback would be a most valuable feature.
- Investigating CD-ROM, index and image database features
- Making better usage of the tracking feature of the individual student statistics
- Giving special access privileges to teaching assistants (course graders)

Learning Differential and Integral Calculus is greatly assisted by a web site that mirrors the course development. WebCT is an important curriculum tool and its various features can be investigated and adapted over time. Learning WebCT with Acrobat and DreamWeaver is best accomplished within the framework of a structured workshop. The various types of pages and features of the product allow for better organization, accessibility and understanding of the course materials and indeed is worth the time and energy invested.