Computer Use in Calculus at WPI

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Worcester Polytechnic Institute (WPI) is a college of science, engineering, and management located in Worcester, Massachusetts. It has an enrollment of about 2500 undergraduate and 650 graduate students. It operates on an academic year calendar of four seven week terms and most courses meet four hours a week. The basic mathematics sequence is four terms of calculus, one term of differential equations, and one term of linear algebra. Collectively, this material is referred to as "calculus."

Since many of the national concerns about calculus courses have relevance at WPI and since WPI was in the process of reexamining the freshman-year experience, in the fall of 1987 the department of mathematical sciences initiated a review which was to result in a revision of the basic math sequence. By the end of April a pilot program had been approved for implementation in September, 1988. At the beginning of the fall term we had 96 freshmen enrolled in three sections of the first course in the pilot sequence.

We identified four goals for action: change the orientation of calculus away from an emphasis on techniques to an emphasis on understanding the concepts of calculus; develop educational strategies so that calculus will conform to the students needs in the post-caclulus workplace; develop applications that will help motivate students to a better

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understanding of the uses of calculus and foster a problem solving approach that will lead students to question and think; integrate computers into the sequence for use by instructors and students.

It was seen that topics in the basic sequence could be profitably interwoven. For instance, there are topics in differential equations that can be appropriately taught at several places in the calculus; linear algebra can be employed to present several differential equations topics.

The availability of calculators and computers with symbolic manipulation capabilities raised questions about which kinds of topics should be taught and how they shoud be taught. We decided to utilize existing PC labs rather than require a calculator with symbolic manipulation. We rejected the idea of attempting to write our own software and decided to use commercially available software.

An intensive review of text books and software began in April. Over a period of three months we reviewed 16 calculus books and 12 software packages.

Among the factors that led to a final text book decision were treatment of basic concepts, exercises with an applied flavor, exercises that could be adapted for computer use, and the placement of numerical methods of integration in the integration chapters. We wanted it close to the definition of definite integral, not tucked away at the end of an applications chapter, since numerical integration is taught before the Fundamental Theorem is studied. By June we had narrowed our choice to Calculus, 2nd ed., D. D. Berkey, Saunders College Publishing;

Calculus with Analytic Geometry, R. A. Hunt, Harper and Row; and Calculus, J. F. Hurley, Wadsworth Publishing. The final choice, heavily influenced by the applications included, was the Hurley text.

We are not programmers and did not want the course to involve programming. Desired features for a software package included: symbolic differentiation that could be used to find routine derivatives needed as parts of applied problems; graphics, both plane curves and surfaces in 3-space; modules that would encourage students to experiment with calculus concepts; adaptability for use in classroom demonstrations. No single package had all of these. There were three that had elements of what we were looking for. COMP-U-CALC, TrueBASIC Calculus, and Calculus-Pad. All three have been made available in the PC lab for student use, but COMP-U-CALC is the primary software tool for the first three courses in the sequence.

COMP-U-CALC has several attractive features that provide nice classroom demonstrations, and we are also using it for student assignments. Functions that are defined piece-wise can be entered, and limits and continuity can be explored using the plotting and tabulation module or the programs in the module on limits. There is a program that allows for epsilon-delta chasing. Also, we have used the bisection module in conjunction with the intermediate value theorem. Parts of the derivative module were helpful in the development of the derivative idea, but the symbolic differentiation program is not very useful for our purposes; it is slow and runs out of memory if the function is only modestly complicated. As we move ahead in the course

sequence we will be using the the integration and applications of integrals modules. There are nice graphics, particularly for solids of revolution. In addition, it is easy for students to print the screen to provide hard copy for homework problems.

Later in the sequence, we expect to make greater use of Calculus-Pad. The surface graphing feature should be particularly useful in multivariable calculus.

TrueBASIC Calculus provides helpful classroom demonstrations and students should use it for some experimentation. The symbolic derivative program is fast, but does not simplify.

The text book and software selection process is not finished. We have to decide on a differential equations text and will be looking for a text that combines differential equations with some linear algebra. In software we will be looking for programs to handle the usual numerical methods for first order differential equation, second order linear differential equations, and systems of differential equations.

Reference has been made to classroom demonstrations. Although the AT&T 6300 is the PC available in our computer lab, in the classroom we use a portable Datavue 25 connected to a PC-Viewer. The PC-Viewer uses an ordinary overhead projector to project the content of the computer screen onto the classroom screen. The image is quite satisfactory and the classroom does not have to be darkened.

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