Computers-in-Calculus: an Experiment at the University of Michigan-Dearborn.

by

John Frederick Fink, Margret Höft, David James

At the University of Michigan-Dearborn, three out of twelve sections of first semester Calculus offered in the fall semester 1988 use computers as a tool for teaching calculus. Preparations for the three sections started in March 1988 with a survey of mathematics departments where computers are used in calculus instruction. Information gathered through the survey and the current literature on the topic of computers in mathematics instruction led us to the conclusion that the use of the computer can strengthen the calculus course, and plans were made to use local resources to establish the pilot project Computers-in-Calculus for three sections of Calculus I. The instructors of the three experimental sections agreed that:

(1) Teachers should use the computer for classroom demonstrations of the concepts and applications of calculus.

(2) Students should use the computer in two ways: they should have access to computers in an unstructured setting to work on homework assignments that require the use of a computer, and to explore the available software. They should also be required to attend a supervised structured laboratory session, where specific computer exercises are completed. These computer exercises and problems should be designed to reinforce the concepts of calculus, and the computer should play an <u>essential</u> role in their solution.

(3) One of the software packages used by the students should be in the form of a tutorial, encouraging exploration and experimentation, and one software package should have some symbolic manipulation capabilities. All software used by students should require no previous experience with computers, in particular no knowledge of a programming language, and it should require only minimal instruction for use.

Hardware The University of Michigan-Dearborn currently has only one classroom equipped with 30 IBM PC work stations. Blocks of time were reserved in this classroom for the supervised laboratory sessions. The University also has one microcomputer laboratory with a variety of IBM

compatible machines that have recently been networked. This laboratory is accessible to any student who pays a fee of $7.50, and it is the principal site for unsupervised work with the calculus software. Engineering students can also use the laboratories in the School of Engineering. The School of Engineering maintains a Macintosh laboratory and a Zenith laboratory, and the calculus software is available in both.

Since no hardwired lines to the University's main frame computer are available in classrooms, the use of a microcomputer was the only reasonable choice for demonstrations in the classroom. All three experimental sections use the same computer, a Zenith ZW/158 with a hard disk, color graphics adaptor, and an 8087 arithmetic coprocessor chip. This computer belongs to and resides in the School of Engineering, is mounted on a cart, and is wheeled to each class session by the instructors. For classroom display, a Kodak Datashow LCD panel is used in conjunction with an overhead projector and a screen. These items belong to the University's Audio Visual Department and are delivered to the classroom by a student assistant from the Audio Visual Department. The equipment is then assembled by the instructor before class and disconnected after class, and the computer has to be returned to the engineering laboratory by the instructor. This is not an ideal classroom situation, where the equipment is securely installed in the classroom and no moving and assembling needs to be done.

Software Software was chosen to meet the requirements in (3) above. An additional requirement was of course that it had to be compatible with the computers to be used in the project, and it had to be commercially available immediately. To accommodate various configurations of hardware, three different versions of *MicroCalc* by Harley Flanders [1] were purchased and installed on the networks (site licences were obtained). This package has some symbolic capabilities and is very easy to use. As a tutorial, the students use *Exploring Calculus on the IBM PC* by John B. Fraleigh and Lewis I. Pakula [2] . For demonstrations in the classroom, the instructors use the same two packages, but occasionally other software (e.g. [3] and [4]) is brought in.

Laboratories The experimental calculus sections are in design similar to a laboratory course in the sciences. Students in the experimental sections like those in the traditional sections meet with their instructor in a regular classroom

setting four times weekly for lecture and discussion. In addition, the students in the experimental sections attend a weekly computer laboratory session supervised by their instructors and three student assistants. During this one and a half hour session, the students work through a four to six page handout of carefully selected computer experiments designed to explore in detail one of the concepts covered during the week's lectures. These handouts were written by the instructors, and topics include the derivative of a function, linear and quadratic approximations, Newton's method, the definite integral, etc. Students work in teams of two per computer work station, but discussion, interaction, and comparing of notes between teams is encouraged. Each team submits a laboratory report based on specific instructions at the end of the laboratory handout. The report is due one week after the lab session, and to increase the students' written communication skills, it has to contain a short discussion of what kind of mathematical questions were covered during the laboratory session. The report also contains solutions to problems, references to theorems used to obtain the solutions, and screen dumps of graphs as specified in the instructions for the lab report.

Each week the students are given a "discovery problem". These problems are meant to challenge the better students. They usually go somewhat beyond the material covered in the lectures and require the use of the computer and some ingenuity. Students use the microcomputer laboratories to work on the discovery problems and to finish up their lab reports. The three student assistants that help with the supervised laboratory sessions, are also available for help during the rest of the week. Two are senior students of mathematics, one is a senior student of engineering, and they spend up to ten hours per week in the microcomputer labs to work with the calculus students in the pilot project.

Midterm evaluation We have 71 students involved in the pilot project, and their initial response has been positive. When the students registered for courses, they did not know they were signing up for experimental sections, and during the first week of classes they were given opportunities to change to traditional sections if they wanted to. Only three students wanted to change, and many expressed enthusiasm for the project. Most students have attended the laboratory sessions regularly , and their lab reports have generally been of high quality. They seem to enjoy and discuss calculus more than their counterparts

in the traditional sections. We plan a more careful evaluation of student reactions at the end of the semester.

The laboratory part of the pilot project is working well. The software turned out to be as user friendly as we had hoped. Even the students without any previous computer experiences had no difficulty understanding its layout, and they found the programs easy to use.

Computer demonstrations in the classroom are a problem. It takes too much time to assemble the equipment. Ideally, it should not take more than the flip of <u>one</u> switch to get the whole system started. LCD panels are not ideal projection devices. They are temperamental, do not project color, and the fluorescent lights in the classroom interfere with the image. The lights ought to be off for better visibility, but that makes lecturing on the blackboard impossible.

We are trying to get better projection equipment for next semester. We have also purchased copies of Maple and Mathematica, and plan to integrate them into the project next semester.

REFERENCES

[1] H. Flanders, "MicroCalc", MathCalcEduc, Ann Arbor, 1988.

[2] J. B. Fraleigh and L. I. Pakula, "Exploring Calculus with the IBM PC", Addison-Wesley Publishing Company, 1986.

[3] K. E. Petersen, "A Computerized Calculus Tutorial for the First Semester", Harper & Row Publishers, New York, 1988.

[4] B. K. Waits and F. Demana, "Master Grapher", Addison-Wesley Publishing Company, 1988.

Department of Mathematics and Statistics
The University of Michigan - Dearborn
Dearborn, Michigan 48128