# The Pilot "Calculus with Computers" Course at Appalachian State University. *

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## 1. Introduction

### 1.1. The Rationale.

Currently there is a national focus on the calculus curriculum. While technological advances have come extremely rapidly, changes in curriculum have moved very slowly. For lack of resources, we are teaching "cookbook" calculus – this approach is no longer relevant, we need to update our curriculum to properly serve the present audience. Just as logarithms have shifted from a computational necessity to a conceptual tool, we need to shift our students' view of the computer as a calculating device to a view of the computer as a manipulator of concepts. We must alter our pedagogical approach to calculus and remove the limiting components by relegating them to microcomputers. Further, we must teach our students to make full use of the analytical properties of the machines. The challenge lies in making use of microcomputers without forcing the students to become Computer Scientists. They must be shown how to use the computer as a tool.

Because of page limitations for the manuscript, we will be extremely terse in our descriptions; we do invite and encourage any interested correspondence.

### 1.2. The Project

With the arrival of new computer systems with graphically oriented interfaces and software packages that allow symbolic manipulation, we have the tools necessary to build a new approach to the calculus. We envision a classroom where the instructor has the materials available to utilize the computer both as an oracle to provide instant nontrivial examples and develop motivation, and also as an assistant to work quickly

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through the many possibilities of approaching a concept, i.e. an assistant that handles "what if ?". We also wish to introduce the student to the computer as a conceptual tool, not merely to regard the machine as an incredible calculator that also plays games. In this vein, we used an existing microcomputer lab and portable demonstration units to augment our calculus course; we also employed a supplemental text for the computer related material. The students were led through introductory material concerning the computer but were not taught programming. We feel it is counter productive to teach simple programming to calculus students when very powerful sophisticated packages are available.

## 2. The Pilot Course

### 2.1. Development

During the summer of 1987, texts were reviewed for use in the project. At this time we decided to use the format of four normal one hour lectures (as in our traditional course) with the instructor having access to a demonstration unit and an additional one hour per week of laboratory time where machines would be available to the students. In order to accommodate the extra lab hour, a "special topics" course number was used with a notation on the transcript regarding the equivalence to Calculus I; to account for the extra time, the student earned five, instead of four, semester hours.

### 2.2. Materials Used

We looked at many texts and chose to adopt Oberle's Calculus and the Computer to supplement Swokowski's Calculus with Analytic Geometry.

We used a microcomputer laboratory which had seven IBM Personal Computers, six Sperry IBM PC compatible machines, and fourteen Apple ][e microcomputers, and, for classroom demonstrations, an Apple ][e or the author's Macintosh. The Apple ][e's were consistently chosen by the naive computer users. The software used included the Waits–Demana Grapher, ArbPlot, Basic with the programs written in Oberle or by the instructor, along with True Basic's Calculus module for classroom demonstrations.

### 2.3. Strengths and Weaknesses

The main strength was that the students' graphical perception was greatly enhanced and the geometric intuition that was developed as a result was markedly superior to that of students not using the microcomputer. The students demonstrated a willingness to experiment with unusual functions and began to exhibit the ability to

derive conclusions from the results — not just the normal application of formulæ to expression that is the routine of present "cookbook" calculus classes.

The main weaknesses were the limited equipment and software available. The existing microcomputer lab was used for the pilot project, but was not suitable for permanent use for various reasons. Foremost was the lack of an instructor workstation for teaching purposes; also the lack of uniformity in the equipment rendered the laboratory inappropriate. These problems made it very difficult to conduct a reasonable size class without getting lost in the intricacies of the different machines. In addition, this room also experienced a very heavy demand from the computer science courses and there was much competition for time on the computers. The laboratory could not carry the increased load of additional students with any reduction in time necessitated by use as a classroom.

### 2.4. Students

The class consisted of majors in Mathematics Education (40%), Computer Science (30%), Mathematics (20%), and others (10%). Of the Math. Ed. students, almost all were recipients of the North Carolina Teaching Fellows award. This scholarship program seeks to enhance the quality of teachers in North Carolina by attracting and supporting the brightest students. Sixty percent of the students had never used a computer prior to the course. Three students had completed previous computer science courses.

## 3. Laboratory Under Development

### 3.1. Machines and Software

We have chosen the Apple Macintosh SE microcomputer with an internal hard disk drive HD20 as the student workstation. The Macintosh has a graphically oriented interface to its operating system that is well suited to the novice – we don't have to "teach the machine" to the extent necessary with IBM compatible equipment. For the instructor we have a Macintosh II microcomputer with a color monitor and an interface to an overhead projector. The Macintosh II's capabilities and expansion possibilities make this a very attractive choice for many different users. We have already been approached by the Math. Ed., Computer Science, and Statistics faculties who are interested in using the lab.

Our major software is University of Waterloo's Maple. This is a symbolic algebraic manipulation system which is the next generation of programs stemming from Macsyma, Reduce, etc. Maple has libraries for calculus, statistics, linear algebra, and

finite groups, just to mention a few. Due to the size of Maple and its libraries, a hard disk is a requisite feature. We will also make use of several smaller programs when appropriate; e.g.: Waits–Demana Grapher, Venn (a logic program), the True Basic Calculus Module, etc.

### 3.2. Logistics

The mechanics of converting a classroom to a laboratory are difficult. The necessary furniture, rewiring, and refitting the facility are small parts of the problem. In the large, it is much more difficult to find space that can be released from the classroom pool – at all universities classroom space is at a premium. Coordinating orders, storing partial shipments, and actually setting up the equipment takes much time and energy, and shows the benefit of our having an excellent support staff.

## 4. Laboratory Manual

Dr. J. Fiedler (Ohio State) and the author are preparing a laboratory manual in the style of chemistry / physics laboratory manuals that guide the student through experiments designed to elucidate the concepts. The manual focuses on the Macintosh computer running Maple. We have contacted several publishers who have expressed interest in the project.

## 5. Future Directions

The next phase is to expand the number of courses that the lab services – discrete math., computer science, and statistics are all natural targets. We also plan to connect the laboratory network to the university's VAX system through Ethernet and utilize the VAX as a file server to hold software and distribute assignment files, etc.

A second project is being developed by Prof. A. McEntire of ASU in a completely new direction. We are considering using the laboratory for summer workshops for in–service teachers and school systems' computer coordinators, both at the elementary and secondary levels, to work towards certification in computer literacy and to introduce them to software and methods appropriate to their classrooms.

## 6. Acknowledgments

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