Using a Computer Lab to Teach ODEs at UoP

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The Mathematics Department of the University of the Pacific received an Instrumentation and Laboratory Improvement Grant (ILI) from the National Science Foundation in 1988, to construct a computer laboratory for teaching calculus using interactive computer graphics. Since its construction, the laboratory has also been used to introduce computer graphics in the beginning ODE course. This report briefly describes the hardware and software configuration of the lab, and how the laboratory has been used to introduce computer graphics in a beginning ODE course.

Laboratory Description. The laboratory consists of 24 Macintosh SE's on an Appletalk network, supported by an Apple LaserWriter. The laboratory is also networked to the University's central computer, a VAX running VMS. Using Versaterm, each Macintosh can emulate a Tektronix graphics terminal to connect to the VAX. This provides the capability to work in two major computing environments. Two portable computer projector set-ups provide the capability for presenting computer graphics during classroom and laboratory lectures.

The primary ODE software currently used is from **MATHLIB**[1], a mathematics library resident on the central computer, and **ODETOOLKIT**[2], a collection of interactive modules which uses **MATHLIB.**

MATHLIB includes a graphics package, **TEMPLATE**[3], and a number of ODE solvers, based on the public domain package **ODEPACK** obtained from the Lawrence Livermore National Laboratories.

Due to current limitations of the VAX, the laboratory has only been used as an open laboratory for ODE courses. The University is upgrading its VAX configuration so that it will be possible to run laboratory sessions using **MATHLIB** in fall,1992.

Use in ODE Courses. The use of computer graphics to supplement the text is the first objective of the ODE course. Lectures have been expanded to include graphics demonstrations. Students are assigned homework problems from the text which are to be done, in part, using computer graphics.

A second objective is to provide opportunities for interactive exploration of differential equations. Lecture-demonstrations have an interactive dimension because there is an easy way to answer "what happens if..." questions in class. These activities continue in individualized work.

These objectives are achieved by writing instruction sheets and short sample programs using **MATHLIB**. The programs are electronically mailed to each student in the class, who then edit the programs to adapt them to individual problems. In some cases the interactive modules of **ODETOOLKIT** are sufficient for the problem. These modules are easy to use because they are menu-driven, thus avoiding the need to program in **MATHLIB**.

To facilitate these objectives, it has become necessary to add material on

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numerical methods at an early stage of the course. The goal is not so much to provide a condensed course in numerical analysis, as it is to sensitize students to the difficulties which can arise and to show them how to recognize erroneous information on the screen.

Clearly there is a higher cost in learning to use a library such as **MATHLIB**. What is gained are added capabilities not frequently found in the first generation of ODE software for micro computers, and familiarity with a professional software library.

Examples. The extended capabilities of the **MATHLIB** library have made it useful in meeting the visualization objectives of the course:

- A standard textbook problem asks the student to plot the isoclines as level sets of a rate function on a slope field and then the solutions. **MATHLIB** accomplishes the task easily.

- Using ODE solvers to compare solutions from a variety of numerical methods, e.g. comparing adaptive and non-adaptive methods with the true solution. **MATHLIB** has a wide variety of professional quality numerical methods, both adaptive and non-adaptive. The package also has the capability to plot an algebraically defined true solution.

Conclusion. Student reaction has ranged from excitement as they learn to visualize concepts and make discoveries, to frustration with the inevitable error messages and equipment breakdowns. When approached with the proper spirit, students respond well as explorers of a new technology and appreciate the added dimension of visualization.

Current software environments do not seem to combine the ease of user control with the required mathematical and graphics capabilities at reasonable financial cost. It is clear that the tools for scientific visualization are in a developmental stage. But then, hardware and software will only evolve to better meet the needs of mathematics if mathematicians make these needs known. Trying to develop these new curricular dimensions for the laboratory has helped to define these needs.

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[1] Registered Trademark of Innosoft International Inc., Claremont, CA

[2] **ODETOOLKIT** is currently under development at Harvey Mudd College.

[3] Registered Trademark of TGS, San Diego, CA. ❑

Lab Development Opportunities

The ILI program anticipates making a small number of awards in FY 1993 for innovative pilot projects that have potential to provide national models for undergraduate laboratory instruction. The purpose of the ILI-LLD is to support the extensive development required to undertake fundamental reform and improvement of undergraduate laboratory instruction. Proposals submitted in the Leadership in Laboratory Development category may address content, methods, modes of operations, new technology, or the contexts for science, mathematics and/or engineering education. Budgets for ILI-LLD proposals may include reasonable costs in any category normally allowed by NSF. Requests for up to $100,000 are permitted. Individuals or groups wishing to consider this option should contact an ILI Program Director at (202) 357-7051.