Poster Session for ILI Projects
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The Advanced Mathematics Computer Laboratory

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Technology has changed the ways in which we teach mathematics courses. For example, instructors can use a "behind the scenes" approach to convey key theoretical concepts and to strengthen the students' understanding of the connection between a solution and its meaning in relation to an applied problem. In addition, technology can be used by students to gain a better understanding of the subject matter. This presentation focuses on the computer laboratory assignments that take place in the Advanced Mathematics Computer Laboratory at Georgia Southern University by students in our upper level undergraduate mathematics courses (i.e., courses beyond the first year of calculus). Experimental problems in which students are asked to make conjectures and applications projects in which students explore solutions to "real-world" problems will be on display. Sample assignments from topics such as multivariable calculus, differential equations, linear algebra, and applied mathematics will be included in the presentation.

An Alternative Technology-Based Mathematics Curriculum

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Grant Number: DUE–9552147

The purpose of the ILI grant our department received in Summer 1995 was to support our vision of an alternative technology-based mathematics curriculum that any technical major coul d pursue at least through the sophomore year. The courses affected by this project include three standard lower division sequences: College Algebra and Applied Calculus for business majors; Precalculus, Calculus I, and Calculus II for physical science majors; and Linear Algebra and Discrete Math for math and computer science majors. These sequences form the three branches of a technology track. Courses in each branch are vertically coordinated to ensure continuity of instructional delivery, classroom activities, testing, and technology and software. Students are free to move on or off the track to more traditional sections at any time, although they are advised to remain on track. Grant moneys were used to equip a new classroom laboratory of PCs and upgrade a previously existing classroom.

This project is an outgrowth and extension of two other NSF-funded reform projects in which the department has recently participated. The first of these, the so-called Interactive Math Text Project, was a n ationwide effort whose goal was the development of potent examples of mathematics courseware using widely-available computer algebra systems such as *Maple* and *Mathematica*. The second project was a local attempt to develop a revised syllabus for College Algebra based on unifying themes, technology, and laboratory experiences. As a result of these projects, the department had developed a good deal of original course material and offered many reform-style or technology-based sections, but on a scatter shot and pilot basis, as resources permitted, rather than according to a coordinated scheme. Students usually were forced to follow a lab-based, computer-intensive section with a traditional lecture section, or vice versa. We felt that the natural differences in presentation styles, modes of assessment, and emphasis on numerical versus analytical techniques must be disruptive for students, especially for under prepared students for whom even superficial inconsistencies can be distracting . We believe it is crucial that students be given the chance to reap the rewards of instructional modes specifically designed to improve their mastery and alter their perception of mathematics. Without a comprehensive strategy, we felt it would be impossible to gauge the true long term impact of technology and lab experiences on mathematical literacy and retention, either here or in similar programs. In our presentation, we hope to demonstrate the general equipage of our two laboratories, the common design framework that is used to create or adopt courseware in each branch of the technology track, the ways in which courses in each branch are interfaced and coordinated, and the role the software plays in each course. Plenty of sample courseware, both software and textual material, will be displayed.

Calculus in a Real and Complex World

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Grant Number: DUE–9351380

The Department of Mathematics and Statistics at UMASS-Amherst now offers two mainstream calculus courses. One is a traditional course requiring the use of graphing calculators, and the other is a course designed by former UMASS Professor Frank Wattenberg that engages students in active learning by focusing on examples of the application of calculus. These applications are "serious" in that the computer is used to get answers that would be very difficult to carry out by hand calculation.

Wattenberg's textbook *Calculus in a Real and Complex World* is the required text. The course meets four times a week. In addition to attending three lectures each week, students in the course also meet in our ILI–funded computer laboratory once a week. Using the MATHEMATICA software, students see demonstrations of concepts learned in class, experiment, make observations on their own, and learn how to solve calculus problems on a computer.

Our poster session will feature photographs of students using the lab, sample term projects, local newspaper clippings, and sample lab exercises in the form of MATHEMATICA notebooks. We will also demonstrate the alpha test version of POLYA, a program designed to collect and collate student grades from a variety of sources. POLYA is designed to run on a computer lab server and collect grades from both lecturers and lab instructors entered from any lab computer.

Classroom Equipment for Instructional Enhancement of Eight Post-Calculus Mathematics Courses

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Grant Number: DUE–9451466

The Mathematics Department has equipped a mathematics classroom with a computer and is currently furnishing a computer laboratory to enhance the instruction of eight post - calculus courses servicing the needs of mathematics, computer and information science, secondary mathematics education, science, pre-engineering and premed students. The targeted courses include probability, statistics, linear algebra, differential equations, numerical analysis, a math course designed for prospective teachers and a problem solving seminar. The Department plans to integrate the computers both for classroom instruction and for student laboratory projects. The content and the presentation of the courses are being revised and instructional materials are being developed.

The classroom has a Compaq Prolinea 4/33 with 16MB computer with Mathematica and other software suited for the targeted courses installed. The computer is connected to two Mitsubishi 37" monitors which are mounted on the ceiling. Space has been designated by the College for the computer laboratory. Architects plans have been finalized and funding for the renovation of the space provided and the purchase of furnishings have been approved by the College. The laboratory will be equipped with 21 networked workstations. Workspace will be provided for two students per computer. Two printers will serve the laboratory. The laboratory will become operational during the Spring 1996 semester.

Since the installation of the computer in the mathematics classroom, instructors have been better able to present topics both graphically and numerically and thus deepen the students' understanding of core ideas of mathematics and the classical interplay of arithmetic, algebra and geometry.

Collaborative Learning through Interactive Animation for Mathematics

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Grant Number: DUE–9451689

Our project encourages collaborative behavior among students through group interaction with animated software within the class period, and with group projects done outside the class period. Our project combines the Harvard approach to reform calculus and precalculus with an approach pioneered by Triesman and adapted by Sher and Wilkinson to the community college environment.

We are developing interactive laboratory assignments that illustrate precalculus concepts. In these labs, the students to interact with mathematical constructs, such as lines and parabolas, and use the computer together as a group to solve problems involving linear and quadratic equations and trigonometric functions. The computer presents functions algebraically, graphically and numerically.

Group projects in data modeling force the students to understand data and use graphical, numeric and algebraic approaches to the data. The students develop linear quadratic and exponential models of a public domain data set for 3 projects. They performed algebraic manipulation in constructing the models, graphical manipulation when presenting the models and numerical analysis when measuring the error between their models and the actual data. Sher and Wilkinson found that their success in encouraging group effort led to a six-fold increase in enrollment in their higher level calculus courses and a substantially increased minority enrollment.

Computer Algebra Laboratories for Business Calculus

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Grant Number: DUE–9451597

The calculus reform movement of the last decade was, in a large part, spawned by the realization that too much of calculus education had become just a sequence of rules and techniques. Lost in the process was much of the understanding of the mathematical concepts underlying these techniques and many of the practical applications of these concepts.

These problems are as applicable to the "Business Calculus" or "Brief Calculus" course. The students in these courses often have algebraic skills that limit their ability to handle complicated techniques or realistic applications. Moreover, one could argue that these students have every bit as compelling a need to come away from the course with a firm understanding of the concepts.

We have been using interactive worksheets and formal computer laboratories in several sections of our Business Calculus class. Our goals have been to encourage participation and mathematical conversation among the students, to emphasize concepts rather than formulas, to promote experimentation, to show that the same problem can be approached from many points of view including graphical, numerical and analytical, and finally to present these students with tools that will enable them to solve problems that are based on some semblance of a real-world application.

We use Maple worksheets in one-hour labs approximately every other week. A typical lab worksheet cannot—by design—be completed in a single lab session. Most assignments include a writing component on some aspect of the work covered in the lab. Typically, we design the labs so that they use material that has just been covered in class. However, most labs do introduce some new material. This is partly based on the conviction that students learn best what they discover themselves and partly on the fact that we have given up class time for these labs.

As one might suspect, the experience has had both positive and negative aspects. We will show some examples of the kinds of exercises that students see in our labs and describe the successes as well as the failures. We feel that we have been able to generate more enthusiasm than we had ever experienced before. It is not unusual for us to see students actually discussing and even arguing over mathematics during a lab session—something we had never encountered before in this class. Some key concepts (such as the relationship between the slope of the tangent line and the rate of change or the connection between local extrema and horizontal tangents) seem to be understood on more than a superficial level.

A Computer Algebra System for Calculus

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Grant Number: DUE–9452472

A computer laboratory for calculus instruction was partially funded by a 1994 NSF/ILI award. The PI's implemented the first phase of the project, Maple laboratories in Calculus I, during Fall semester, 1995. As most of their calculus students are prospective engineering majors at the University of Kentucky where they are expected to have skills from a traditional course, the LCC project has taken a middle of the road approach. They maintain most traditional topics, but have reduced their technical expectations. Mr. Ott and Ms. Crowley encourage the use of Maple as a tool to enhance the course. A dozen laboratory exercises during the semester use the CAS to permit exploration of problems that are not straightforward and that require more difficult computations. These are worked in groups, with the finished report being submitted by the group.

Rather than rely on a commercially available Maple manual, Mr. Ott has written one that is tailored to the course. The examples and problems in the manual provide an additional learning tool, and support specific features of the Maple language that are needed in a calculus course.

The laboratory is equipped with 8 networked Hewlett Packard pentium p.c.'s, each with a 17" monitor, arranged on two four-leaf clover shaped tables. The p.c.'s are each set at the back of a leaf, leaving a large semi-circular workspace in front. The configuration facilitates discussion and collaboration, and encourages use of the computer as a tool.

During 1996 the project is being expanded to include Calculus II and III, and supplements to the manual are being written to support these courses.

Computer Classrooms for Upper Division Mathematics

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Grant Number: DUE–9552394

Monies from this grant funded computer equipment for an 18-person computer classroom and enhanced an existing 24-person computer classroom. The new classroom was designed for use by our smaller upper division mathematics courses. This year courses in Data Analysis, Linear Systems, Multivariable Calculus, Real Analysis, Differential Equations, Mathematical Modelling, Mathematica, and Chaos and Fractals have been taught in these rooms. During non-course hours, the room doubles as a laboratory for Calculus courses or as an open computer room for students.

Having a computer classroom, rather than separate computer labs, allows immediate and spontaneous use of the computer as an exploratory teaching and learning tool. The atmosphere in such a learning situation is different than that of a traditional classroom or a traditional laboratory.

Various software has been utilized in the different classes. In Linear Systems and Multivariable Calculus, MATLAB and Derive have been used for in-class demonstrations and independent student investigations on such topics as linear transformations and change of variables. In Real Analysis, Derive has been used as an exploratory tool in investigating such ideas as the convergence of sequences and series, or continuity and uniform continuity of functions. In Data Analysis S-Plus is used to analyze data sets. In Differential Equations and Chaos and Fractals, students and faculty have written programs in Tru-Basic to study vector fields, integral curves, and dynamical systems.

Our poster will describe our equipment and facilities and give examples of how we are using them. A handout will be available detailing the facilities, which may be of use to other institutions designing computer classrooms. We will also distribute curricular materials we have developed which take advantage of this technology.

A Computer Classroom/Laboratory for Undergraduate Mathematics Instruction

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Grant Number: DUE–9352676

The computer laboratory provides a classroom environment that was initially utilized primarily for teaching a course entitled "Computational Techniques for Mathematics and Science" (CTMS). Enrollment in CTMS consists of post- calculus students who are mathematics and engineering majors and students seeking secondary mathematics teacher certification. Students explore a wide range of problems in mathematics by utilizing both Maple and MATLAB. This course includes topics that develop skills in numerical computation, symbolic manipulation and programming, as well as applications of the graphical features of these systems. The course is built around applications of calculus, linear algebra and ordinary differential equations. Specific projects deal with aspects of numerical and symbolic integration and differentiation, approximation of functions and curve-fitting, Fourier series, and initial value problems. For example, students solve algebraic linear systems and ordinary differential equations where issues of conditioning are emphasized as they investigate the interplay between floating point calculations and exact arithmetic at the expense of increased computational resources. For the most part students utilize the built-in features of the systems, but do spend some time writing simple programs that implement quadrature methods and numerical ode solvers.

The laboratory, which consists of 25 X-terminals connected to a Sun workstation, is also utilized in teaching an honors calculus sequence that uses Maple, numerical analysis, and some sections of linear algebra. During the summer a workshop is conducted with participants primarily secondary mathematics teachers from area schools who have begun to incorporate computer algebra systems into their classroom instruction.

Our poster presentation will include examples of Maple worksheets from our CTMS class, some handouts describing the lab and its use in undergraduate mathematics education and some pictures of the lab in use.

A Computer Laboratory for Mathematical Exploration

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Grant Number: DUE–9452234

Thanks to a National Science Foundation Instrumentation grant we have set up a computer laboratory for use in our mathematics classes. This has resulted in major changes throughout our curriculum, but the biggest influence is now being felt in the calculus sequence. Some of the features of our project include:

- A two hour laboratory meeting every week in the first two semesters of calculus.
- Laboratory exploration (with Maple) of the most important concepts from calculus before they are introduced in the textbook.
- The use of electronic journals to aid in communication between student and instructor.
- The use of graphing calculators and a reform calculus approach (Dick and Patton) during the other meetings.
- The use of Geometer's Sketchpad in our College Geometry Course.
- The use of Matlab in our Linear Algebra Course.

We will describe the effects of these changes on our students and our curriculum. Sample laboratory projects will be available for inspection.

A Computer Laboratory for Numerical Analysis and Linear Algebra

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Grant Number: DUE–9451805

Our project (DUE–9451805) was to set up a computer laboratory for the instruction of both Numerical Analysis and Linear Algebra. With the funding received, we were able to set up a new lab, and augment another. The latter, which is open about 50 hours per week, now has 15 computers (10 originally), and serves as an open lab. It has adjunct faculty serving as proctors, answering questions, and helping students with various software. Another lab room, with 20 computers, serves as a classroom. It is our intention to use this room for as many of our courses as possible. A dedicated server connects the computers in both rooms, and ultimately connects to the outside world. Various software is available, including *Mathematica* and *Derive*.

These are the points we will cover in our presentation:

- Details of the physical set up and the management of the labs, as well as the problems we had to face in implementing the project.
- How the instruction of Linear Algebra, Numerical Analysis, and some computer science courses have benefited as a result of the labs.
- Classroom materials, homeworks, projects and sample student work from these courses. Also, sample Mathematica and Derive utilities that have been written for Linear Algebra and Numerical Analysis.
- Use of the World Wide Web to make these utilities available for everyone.
- The overall impact the availability of computers and software is having in our curriculum and our teaching practices.

Computer Laboratory Instructions in Multivariable Calculus

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Grant Number: DUE–9452422

In this project, we have developed a public domain MAPLE library that contains various custom programs for the learning and teaching of multivariable calculus. This will be the an electronic marketplace where experienced and inexperienced instructors can exchange ideas and experience.

Also we have developed two versions of Maple Lab manuals which will demonstrate how to use the customized MAPLE programs in the proposed library. The first version of the manual covers the conventional multivariable calculus topics that appear in most standard calculus textbooks. The second version of the lab manual will integrate Maple with the non-conventional multivariable calculus syllabus developed by the Calculus Consortium based at Harvard. Both manuals are published by Wiley. Currently, we are working on the Mathematica version of the material, a draft edition will be available to the public in January.

Experienced instructors will find the lab manual very helpful because it provides a source of programs and suggested ways of using them. They can then adopt the programs to their own lab manual. Inexperienced instructors can follow our manual closely to start an instruction lab. They can choose the topic or format in the manual that is most appropriate to the class. After one or two semesters when they feel more comfortable with the material, they can design their own lab manual based on ours.

Computer Technology Across the Mathematics Curriculum

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Grant Numbers: DUE–9351491, DUE–9551132

The University of Redlands Mathematics Department has used computer technology in its calculus sequence for six years. Computer usage was introduced gradually over two years in the calculus sequence; these courses now make integrated use of computers on a regular basis. Initially, we used small, easily altered programs in TrueBASIC language, and the TrueBASIC Calculus software graphing package to illustrate numeric and graphic limits, and to explore other calculus concepts.

More recently, we have expanded computer use to and in other courses, including pre-calculus, linear algebra, differential equations, probability, statistics, number theory, college geometry, and numerical analysis. In all courses, the computer is used for graphic and numeric exploration of concepts, and/or as a computational tool. Classes are held in three computer classroom laboratories equipped in part through funds from two NSF-ILI grants (DUE-9351491 and DUE-9551132). Students use the machines regularly during class time.

The poster and handouts will illustrate the physical arrangement of our classrooms, provide examples of classroom activities and homework assignments involving computer use in various courses, and give a list of software used at Redlands.

Eastern Kentucky University Mathematica Project

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Grant Number: DUE–9351052

The mathematics faculty at Eastern Kentucky University will use the computer algebra system Mathematica to enhance the teaching of calculus, linear algebra, and differential equations. This will be accomplished through non-traditional instruction which will take place in a technology classroom which has been established with an NSF-ILI grant. The emphasis of the program is to have students explore problems of such computational complexity that they will have to use Mathematica to analyze and solve the problems. It is felt that well structured experiences with Mathematica will lead to good problem solving skills and to a deeper and richer understanding of the important principles of mathematics. In the technology classroom students will be placed in an environment where they will be required to use approximations procedures, graphical analysis, and data analysis in order to solve problems. Computing will be used as a tool for experimental problem solving as opposed to the usual deductive and theoretical approach most often found in the traditional classroom setting. Students will be encouraged to work and learn cooperatively. Also, students will be required to submit written reports on their technology classroom projects.

Mathematica materials will be developed for use in teaching calculus, linear algebra, and differential equations. The faculty plans to build on materials developed under other NSF grants as well as developing new materials. New Mathematica materials developed will be made available to the mathematical community upon request.

Enabling MS-Windows and Windows Based Mathematical Software In Current Computer Laboratory

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Grant Number: DUE–9552225

A summary of the initial (prior to the grant proposal) computer hardware and software available for use by students taking mathematics courses at Towson State are described. This includes equipment and software obtained through participation as an Interactive Mathematics Text Project site. The purposes of the grant request and the goals that we expect to accomplish are discussed. This includes a summary of what we intend to do with the funds, the anticipated changes in the mathematics curriculum at Towson State and the effects on mathematics education in the community served by Towson State University.

A description of what has been accomplished to date is given. This is mainly hardware and software purchases. A discussion of how cooperation with other departments in the College of Natural and Mathematical Sciences may maximize the use of our funds is included. Examples of some interactive mathematics software developed at Towson State University are shown.

Finally, and perhaps the major reason for the posting, is a section for people considering applying for NSF-ILI grants. In this section the strong and weak points of our proposal are described, and some advice for increasing the likelihood of success is given.

Fostering Creativity, Teamwork, and Scientific Thinking in Introductory Statistics through Computer-based Laboratories

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Grant Number: DUE–9552311

Goals of project:

We are revising our course in elementary statistics so that a computer laboratory will be an integral part of the course. This revision involves creating a series of laboratory exercises, using real data, which span one semester's material. The students will analyze various data sets, usually working in groups, after receiving guidance and examples. The laboratory exercises under development are based on the Windows version of Minitab (Release 10 Xtra).

What we have accomplished so far:

We have prepared some of the laboratory exercises and data sets. The titles and purposes of these exercises are as follows:

- Lab 0-A Introduction to MS-Windows to familiarize new users with the Microsoft Windows 3.1 environment
- Lab 0-B Introduction to Minitab for Windows to familiarize new users with the Minitab-for- Windows environment
- Lab 1 Minitab Sample Session to familiarize new users with the operation of Minitab for Windows
- Lab 2 Graphical displays of Data to produce dotplots, stemplots, and histograms, and to describe the main features of what we see
- Lab 3 Measures of Location and Spread; Boxplots; the Empirical Rule to learn about mean, median, quartiles, interquartile range, standard deviation; effect of skewness on measures of center; five-number summary; modified boxplots (with outliers); Empirical Rule
- Lab 4 Regression; Normal scores plots to learn about scatterplots; fitting a straight line to data and assessing the fit; checking for normality

How the funding has benefited our department:

NSF funds are being used to equip a laboratory with appropriate computers and software. This facility will allow us to implement the changes in the statistics course as outlined above. Current (pre-existing) equipment is inadequate.

Implementing Computer Algebra Systems and Writing to Learn in Linear Algebra and Differential Equations

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Grant Number: DUE–9551794

Nebraska Wesleyan University's NSF/ILI grant builds upon the progress already made in incorporating technology into the teaching of Calculus to include the use of *Mathematica* and writing-to-learn in the study of Linear Algebra and Differential Equations.

Our project will

- Improve student understanding through the use of technology for visualization and experimentation;
- Improve student understanding through their written formulation of the mathematics studied;
- Produce competent users of "industrial-strength" mathematical software;
- Improve students' appreciation of the applicability of mathematics to the real world; and
- Produce students able to write lucid mathematical prose.

These objectives will be attained through the establishment of a computer lab with PowerPC-based machines running *Mathematica* and *Microsoft Word*. The lab will be used for a scheduled weekly laboratory period, homework, and projects. Specific writing components will be present in the computer lab experiments, and in application-based projects.

In this poster, we show the planned layout of the computer laboratory, with motivation for its configuration. Examples of the lab experiments that have been developed are given. Specific projects which demonstrate the use of mathematics in real-world applications are also shown, with results from similar projects currently being used in the Calculus sequence which demonstrate their expected efficacy.

An Integrated Laboratory Environment for Mathematics Majors

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Grant Number: DUE–9552095

This grant supports the creation of a Power Macintosh laboratory that will enable the Mathematics Department to standardize its computing efforts around the computer algebra system Mathematica and to extend use of the computer laboratory beyond calculus to courses in differential equations, linear algebra, mathematical modeling, probability, statistics, and other appropriate offerings.

Our goal is that mathematics majors be thoughtful and creative users of Mathematica both to enhance their course learning and to promote effective application of technology throughout their scientific careers.

The grant, in this first year, has already enabled us to set up a smoothly functioning lab and auxiliary mathematics resource center. The lab is already being used by all calculus classes, plus classes in multivariable, and mathematical probability. Mathematica notebooks have already been developed for first year calculus, and notebooks are being refined and used in multivariable calculus.

The grant also encouraged the college administration to support a week long summer workshop for mathematics faculty. In this workshop, led by the Principal Investigator, faculty learned the basics of Mathematica and discussed pedagogical issues as well as issues related to use of Mathematica in specific classes. Initial experience suggests that our choice of equipment (Power Macintosh 7100) was a good one and that students and faculty are using the software and the notebooks effectively.

An Integrated Laboratory-Classroom for Calculus and Precalculus

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Grant Number: DUE–9551646

Before applying for our ILI grant, our department had experimented with various ways of using computers with our calculus classes: sessions dedicated to laboratory projects, integrating the computer with other group work in one of the college computer laboratories. We had also done various experiments with using groups and with using one of the calculus reform texts in preparation, Ostebee and Zorn. Having found out what worked and what didn't with our students, we applied for computers to equip a classroom in which we could easily move from one type of activity to another.

Thus, we have a classroom with 15 tables, each large enough for two students to sit at comfortably or three closely, one computer per table, with the tables separated enough that the instructor can move around the room freely. The point of the flexible sized groupings is that some of us prefer have students work in groups of two, others in groups of three, and this way the whole department can use the room comfortably. We found that in the traditional computer laboratory, computer screens obscure the line of sight between students and board, and between teacher and student. To avoid this as much as possible while still having the computer available without moving around the room, we just have one machine per desk and have it mounted on a swing arm which permits moving it off the desk when not in use. We also had the monitors wired separately from the computers so they could be switched off when not in use to minimize distractions from computer games, e-mail, etc. To allow the instructor to move between groups easily when the students are working in groups, it was important to avoid the long rows of tables found in computer laboratories. Finally, there are blackboards around the room so that students can also work in groups at the blackboards when appropriate.

All sections of calculus are using Calculus T/L II (a front-end for Maple) because its point-and-click style seems to take less start-up time for the students. Sections of precalculus are using Mathematica, since they're basically only using graphing commands. The machines are Macintosh Power PC's which also have MATLAB installed on them for use with linear algebra. There is also an overhead projection system. We are using this classroom with Ostebee and Zorn's "Calculus from Graphical, Numerical and Symbolic Points of View" and with an experimental precalculus text. Time in class is spent on a range of activities most days: interactive discussion between the class as a whole and the instructor; group work on problems with pencil and paper as well as with the machine; overhead demonstrations by the instructor of appropriate ways to use the computer; and sometimes the class as a whole at the blackboard. The classroom makes this variety of activity convenient.

At the poster session we will have, in addition to a description of the project, diagrams and pictures of the room and its use.

Instrumentation and Laboratory Improvement Grant at Gustavus Adolphus College

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Grant Number: DUE–9550977

Through the Instrumentation and Laboratory Improvement grant from the National Science Foundation, which provided matching funds for the purchase of eight Silicon Graphics workstations, Mathematics Education majors at Gustavus Adolphus College are integrating computer visualizations of geometric ideas into the college geometry course. This poster illustrates some of the geometric visualizations rendered by Mathematica, Geometer's Sketchpad, and Non-Euclid 4.0, a program from Rice University.

On the center panel are the five Platonic solids rendered in color by Mathematica. Information on how Mathematica function "Live" makes it possible to examine three dimensional objects by rotating them in space and zooming in for detail is also provided on this panel. Under the heading "Projective Geometry", the software package *Geometer's Sketchpad* is used to illustrate a harmonic range and projectivities between pencils of the Projective Plane. Additionally, one and two point perspective renditions of a box are shown on the center panel.

On the left panel, under the heading "Euclidean Geometry", a Desargues Configuration and the intriguing "nine point circle" are presented. The Desargues Configuration illustrates the fact that two triangles which are perspective from a point are also perspective from a line and conversely. The nine point circle contains the midpoints of the sides of the associated triangle, the feet of the altitudes and the midpoints of the segments joining the vertices of the triangle with its orthocenter. Under the heading "Constructions", the left panel also illustrates several classic relationships between circles and triangles.

On the right panel a program from Rice University, called Non-Euclid 4.0 is used to provide examples of angles of parallelism and also Sacceri quadrilaterals from the Poincare model under the heading "Non-Euclidean Geometry". Above this on the right panel, Mathematica is used to provide illustrations of various transformations of the Euclidean plane. Examples of translations, reflections, rotations and circle inversions are placed under the heading "Transformations", along with an explanation of how to produce animated transformations.

In summary, each of the three panels of the poster is divided into distinct aspects of computer visualizations along with minimal text explanations.

Interactive Learning of Mathematics and Computer Science in a Distributed Laboratory

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We report on the development of an interdisciplinary laboratory course for mathematics and computer science that channels some of the recent technological advances in communications and computations into the undergraduate curriculum.

The course content has been designed for the junior/senior level of the mathematics and computer science curricula, and it builds on topics and concepts in the sophomore level core of both fields. The stated goal of the course is that students learn to use a computer algebra system (Mathematica) to solve problems arising in their major field of study, e.g. in engineering, physics, statistics, mathematics, and computer science. All students are expected to complete and present a major project at the end of the course and they choose a project from their major field of study.

The teaching model is a laboratory course based on an interactive text that has been written specifically for the course. Extensive use of electronic communication allows the laboratory to be located where a student and a computer running the software interact, and where a connection to the Internet is possible.

The course has been offered in Fall 94 and in Fall 95 simultaneously at three very different academic institutions in Southeast Michigan, The University of Michigan-Dearborn, Eastern Michigan University, and Siena Heights College.

We will describe the course, the content, and the experiences teaching it at the three institutions. Course materials, an interactive text for the course, an instructors manual, and a manual of suggestions for student projects are expected to be published and will be available for inspection at the meeting.

Library for the Interactive Study of Mathematics

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Grant Number: DUE–9551273

The problem this proposal addresses is how to use the new information technologies, and in particular, the World Wide Web on the Internet, to make new tools available to teachers, and, through the teachers' productive use of those tools, to enrich the quality of mathematics instruction at the undergraduate level, to widen the range of instruction to include larger sectors of the student population, and to expand pedagogy with new technology- supported styles of teaching and learning. Specifically, there is a need to make interactive materials that already exist easily available so as to encourage more teachers to experiment with the materials, to extend them, and finally to create new materials that are more sharply focused on the level and the abilities of their own students

The proposal is to build, over the course of two years, a Library for Interactive Study of Mathematics on the World Wide Web. This will be an Internet based library of interactive workbooks on topics commonly encountered in undergraduate mathematics. That is, it would cover topics from college algebra and precalculus through multivariable calculus, differential equations, and mathematical modelling. This library would make available to instructors all over the country a wide variety of interactive workbooks that they may freely use and distribute to their students. This means that workbooks, together with the program necessary to read them, will be provided instantly, and free of charge, over the Internet to any teachers who desire to have them. As initial stock for the library, the directors will provide 45 of the most effective experimental workbooks created by teachers during the last three years at workshops of the MAA-sponsored Interactive Mathematics Text Project (funded by IBM and NSF). Initial NSF support for that project came from the 1992-3 NSF ILI-LLD grant: Establishing Regional Sites for the Dissemination of Computer Based Laboratory Materials in Mathematics (USE-9150272).

The plan is to disseminate widely among instructors information about the library, about its contents and about learning with interactive workbooks. Information will be disseminated electronically via email and discussion lists, and the project directors will do presentations and workshops to show teachers what can be done, to get them interested in experimenting, and for those who are motivated enough, to teach them how to build their own interactive workbooks. Collaborators will be solicited to help build the library from a consortium of colleges that have already said they are interested in participating, and others will be invited to join. There is a core group of 8 productive and knowledgable authors in these colleges who are interested in working on this project, and the directors will provide both software and workshop instruction to prepare 16 new teacher/authors to contribute to the library. In order to refine and focus the library collection, the materials will be used in teaching and their effectiveness assayed at the consortium test sites, and feedback from an editorial board will be directed to the authors. The project will be based at the Institute for Academic Technology of the University of NC at Chapel Hill.

MAPLE and Mathematics: Improvements to Four Senior Mathematics Classes

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We describe the work we have done on an ILI-IP project: *A Computational Laboratory/Classroom Learning Environment for Mathematics Majors* (grant # DUE-9452213) aimed at improving 4 senior level courses: Differential Equations II, Partial Differential Equations, and Advanced Engineering Mathematics I & II. The project's goal was to improve these courses by integrating the use of the computer into all aspects of these courses (homework exercises, tests, tutorials, and demonstrations). We used MAPLE as the computer algebra system for doing all computer work and MAPLE's worksheet format proved to be very helpful to the students for doing the exercises/tests and to us for producing tutorials and demonstrations for them. The ILI grant enabled us to establish two labs: one fixed (a traditional computer lab) and one portable (consisting of 12 TI TravelMate 4000E laptop computers). The portable lab turned out to be enormously successful in achieving the project's goals. We describe why this was so, as well as the details of our course improvements.

Mathematica Laboratory Instruction in Calculus and Applied Mathematics

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Rockhurst College began experimenting with alternative calculus curricula in 1990 and became a test site for the Duke University *Project CALC* program in the fall of 1992. Specifically, we were looking for a calculus curriculum that emphasized conceptual understanding, had a demonstrated commitment to modeling real-life applications, and used modern technology as a fundamental tool to both solve problems and present ideas. From the beginning we made extensive use of the laboratory materials developed at Duke University and Bowdoin College that were an integral part of *Project CALC*. Our efforts to build a laboratory-rich environment has recently resulted in the creation of a Mathematics Technology Classroom. The physical and logical design of the classroom has brought some anticipated successes and challenges, and a few surprises.

The Mathematics Technology Classroom was designed for collaborative learning and active student involvement in the day to day delivery of the material and, by design, encourages experimentation with alternative teaching methods. It contains a projection system that sends computer, camera and video images to all the student stations. It is also equipped with a sophisticated sound system to complement the video capabilities. Long term plans include integrating the technology in the room with a campus satelite system to build an interactive mathematics program with area high schools.

Currently we are using *Mathematica* version 2.2.2 operating on a variety of Macintosh platforms all connected to a Sun Workstation fileserver. Technical information regarding the physical layout and the equipment component of the classroom will be provided. Issues of funding, building and maintaining a technological learning environment will also be included. Examples of curricular materials designed specifically around the technology in the room will be displayed.

Mathematical Interactive Network Design (MIND) a Computer Labortory for Developmental Mathematics

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The Mathematical Interactive Network Design (MIND) Project is a computer laboratory designed for interactive multi-media instruction in developmental mathematics. Project MIND has been awarded an NSF-ILI grant DUE–9551581 and an NSF curriculum development grant DUE–9455142. The MIND project is being constructed using SIMPLE (a new software sponsored by an NSF curriculum grant number 9156237). This project's design incorporates notes, directed examples, and exercises to engage the student's mind in an intensely interactive learning environment that simulates the student/tutor relationship. A computer daemon, whose behavior, and even personality depends on the actions of the learner, provides the personalized feedback of a tutor.

Mathematics Computer Laboratory for Individuals and Groups

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Grant Number: DUE–9451984

Although the University of Tennessee Mathematics Department has had a long-standing interest in the use of technology in the classroom, we did not have a suitable computer lab until we received funding from the NSF ILI-IG program last year. UTC contributed more than twice the amount we received from NSF, which allowed us to build a better and larger lab than we had anticipated,

network our building, and connect to the new campus fiber-optic backbone. We will have handouts of our budget, equipment details, and pictures of our lab at the poster session.

Our lab is set up as a computerized classroom with the computers, keyboard, mouse, and monitor under the computer tables; one views the monitors by looking through the glass top built into the tables. This setup allows the instructor to make good eye contact with all the students and makes the room suitable as a combination lab and classroom. We have found that three students can work effectively in a group at these tables using a single computer per group. Although getting permission to convert the room from its previous use as a large classroom to its current use was not easy, and sometimes unpleasant, we were able to secure a room for the lab which allows for 25 computer tables in four rows, with generous spacing between rows and a center aisle. As a result of the spacing, professors and our student assistants can move freely around the room to help students. We currently have 19 student computers, 1 faculty computer, and 2 HP 4M+ printers networked via ethernet with 10-Base-T.

The lab is used for courses in a number of ways: each student working individually at a single computer; students working as a group of two or three at a single computer; as a regular classroom; as an open lab for students to do assigned mathematics projects, work from other courses, use Internet, etc. (we purposely did *not* put a word processor on our server).

Since the faculty member running the lab has only a three hour course release, many of the activities of running the lab, such as computer repairs and regular maintenance, are performed by well-qualified student employees. These students are expected to be familiar with Maple, Matlab, Minitab, Windows, Dos, Mac OS, and various other applications, such as the Internet tools. They can install boards, make changes to configuration files, and troubleshoot problems that continually arise. The faculty lab supervisor has given these students the freedom and power to solve problems with the lab and they have made good contributions to the effective running of the lab in surprisingly wonderful ways.

Multidisciplinary Statistics Laboratory and Curriculum

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Grant Number: DUE–9451814

The grant provided funds to create a classroom/laboratory for statistics in which up to forty students can work in pairs at personal computers or observe lectures and instructions given from the front of the room. The laboratory is being used in restructuring our introductory and advanced statistics courses. A student in an introductory statistics course now enrolls in a lecture section given by faculty in mathematics and in a laboratory section associated with another discipline chosen by the student. The theory of statistics is presented by faculty in mathematics while relevant applications are presented in the computer laboratory by faculty in Economics, Psychology and Biology team teaching the course.

The laboratory provides opportunities for students to learn statistical methods otherwise beyond the reach of an introductory course. It is hoped that the hands-on laboratory experience and the connections to a discipline of interest will also improve students' retention of concepts, but it is too early to measure the effects on student learning. However, the new approach to teaching statistics has produced benefits for the curriculum and the faculty. Because of the involvement of other departments in teaching them, the introductory courses have altered the statistical methods curriculum in the user disciplines. Elementary Statistics is now an integral part of the Research Methods sequence in Psychology, instead of a tangent to the sequence that was often treated by students as irrelevant. With the new courses, minimum preparation for Econometrics is more uniform and advanced than previously, and that course reflects the change. More Biology students are taking statistics than ever before. The interdisciplinary interactions spawned by the project have broadened the backgrounds of the faculty involved. Mathematics faculty are gaining experience with the ways in which statistics is applied in other disciplines. The faculty in the user disciplines are gaining a more critical view of the accepted practices in their disciplines and are learning new approaches to their data analysis problems.

Novel Laboratory Instruction in Undergraduate Statistics Curricula

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The aim of this project is to address some of the shortcomings of traditional methods of instruction, as well as to enrich the scientific content of the undergraduate statistics curriculum. Special emphasis is put on recent advances in statistical/mathematical computing and modern computer intensive statistical methodology. The curricular resources developed under this project exploit the most sophisticated computing and multimedia technologies available to increase students' interest and enhance learning. To that extent we have used funds awarded by the Instrumentation and Laboratory Improvement program, at the National Science Foundation, to establish a high-tech laboratory of unix-based graphics workstations. This laboratory has been in operation for nearly two years, providing support in the implementation of the intended curricular changes under this project.

The materials and methods that are being developed under this project feature active learning to increase conceptual understanding and statistical maturity, as well as extensive use of writing and revision as means of cognition. Real data examples chosen from fascinating applications of statistics are used extensively to provide motivation and to make the subject matter exciting to learn. Finally, the self-paced mode of instruction advocated by the project also facilitates efficiency in the delivery of more quality curricular resources, to more students, without increasing the cost.

Contentwise the project involves several courses, including a foundational laboratory course in statistical computing designed to provide the students with a broad introduction to numerical, graphical, and symbolic computation, an advance course in computer intensive methods, and companion laboratories for a few other courses. The objective is to provide the foundation as well as to initiate a broad revision of the undergraduate statistics curriculum to facilitate the adaptation of rapidly evolving advances in the aforementioned areas of statistical methodology.

In this poster we will present sample curricular resources from some of the courses involved in the project. A multimedia kiosk demonstarting our laboratory setting, including photos and video, as well as student discussions about the project will also be available.

OLS MC-Squared

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Grant Number: DUE–9350999

Our computer laboratory provides support and encouragement to students from underrepresented groups interested in careers in mathematics, science, and mathematics education. The laboratory is housed in the Mathematics Learning Center (MLC), which comes under the administration of the Office of Learning Support Services (OLS). The Center has provided classroom instruction and laboratory support for the past twenty years. The majority of its clients have been and remain women, students of color, and persons with disabilities.

The laboratory computer laboratory serves two primary purposes: 1) It provides a center where students from underrepresented groups learn to explore and solve mathematical problems with the aid of the computer, faculty and tutors. Each week in the targeted classes, problems are assigned which illustrate basic ideas and techniques described in the formal lecture period. With adequate equipment and software, the staff of the MLC support students as they work on these problems. 2) It provides a facility where students work iin groups or individually in a setting that encourages more student-student and instructor-student interaction. Students have come to regard the MLC as a "safe" place where the staff is experienced in teaching mathematics to various ethnic groups.

With the NSF funds and matching ones from the institution, we were able to network 18 Macintosh Computers, a server, and two printers. We also have an LCD display and an overhead projector.

Software used includes: Minitab, LOGO, Maple, Calculus TL, PCSolve.

A Unified Approach Toward Success in Calculus

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Grant Number: DUE–9452621

The Department of Mathematics at The College of Charleston is conducting an NSF project using equipment funded through an ILI grant for a Macintosh computer classroom/lab and Mathematica software in a three-course calculus sequence followed by a linear algebra course. The interactive learning capabilities, along with the symbolic, numeric and graphical capabilities of Mathematica is being used in the computer classroom/lab in conjunction with structured tutoring provided by the mathematics tutoring lab. The focus group is African American students guided toward the two sections of calculus which will be participating in the program. The goals of the project are to

1. increase traditionally underrepresented minority participation in the mathematics major and provide access to other science majors by increasing the ratio of success in calculus and linear algebra;
2. serve as a lead program to guide other institutions to similiar goals;
3. prepare students for the technology of the twenty-first century workplace;
4. increase the participation of more faculty in using computer technology for their courses.

Using an Instructional/Explorations Laboratory to Improve Introductory Level Mathematics

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This model for improving instruction of introductory-level courses (College Algebra, Statistics, through Calculus I) includes three components: (1) enhanced classroom instruction, (2) laboratory exploration modules, and (3) writing activities focused on the lab experiences. Traditionally, at this rural Appalachian university, performance has been poor and attrition rates high. The goals are to improve understanding of mathematics and interest in mathematics; thus, increasing retention rates, performance, and attitudes of beginning students in mathematics.

The presenter will share the progress of this project, i.e., how instruction has changed, data analysis of project to date, laboratory modules developed to use with Derive, Minitab, and Matlab, and evaluation instruments designed and being used.

The presenter encourages discussion and exchange of ideas on the use of technology and group/ independent explorations to improve instruction at this introductory level. Similar programs and the research into their effectiveness is of great interest to me.

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