Fall 1991

Occasional Papers: On Teaching the Sciences

Janice Rowan Poley
Rowan University

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1991

THE HOLLYBUSH SERIES
In 1849, Thomas and Samuel Whitney, glassmakers of Glassboro, New Jersey, built Hollybush, an eighteen-room mansion constructed from brown fieldstone. The mid-Victorian gingerbread house has sheltered such distinguished visitors as Colonel Theodore Roosevelt and President Taft.

In 1917, the State of New Jersey purchased Hollybush and twenty-five acres around it. Hollybush serves as the campus home of the presidents of Glassboro State College, and the College's fifth president, Dr. Herman James, and his family currently reside there.

On June 23, 1967, Hollybush was the site of the first summit conference between a President of the United States and a Premier of the Soviet Union, Lyndon B. Johnson and Alexei N. Kosygin.

Dr. George Neff, Professor of Art at Glassboro State College, created his first drawing of Hollybush, in pencil, several years before the summit. From this original work, two drawings were rendered in pen and ink during the conference.

George presented the first pen and ink drawing to President Johnson at the White House on July 12, 1967. In August, as a member of a delegation of Glassboro citizens touring Russia, George presented a second drawing to a representative of Premier Kosygin in Moscow.
Occasional Papers:
On Teaching the Sciences
The costs of implementing a new era in science education will be high. The costs of continuing to educate undergraduates inadequately in the sciences will be even higher.

—Report from the American Association for the Advancement of Science
Occasional Papers: On Teaching the Sciences

A Collection of Essays by Glassboro State College Faculty

Janice Rowan Poley
General Editor

Fall 1991
Vol. 2
Editorial Board

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Many recent reports have documented that our nation’s technological superiority will not endure unless we improve our math and science education.—Ron Czochor

Outside of Computer Science programs, and courses that directly involve computer skills, ... the use of computers has been minimal.—Mike Berman

Our challenge now is to develop a mathematics program that will attract people instead of turning them away.—Gary Itzkowitz

Our methods in teaching science need to evolve to facilitate learning for all students.—Karen Magee-Sauer

It has become clear that students learn by actively participating in problem solution or discussion rather than by listening to a lecture.—Seth Bergmann

Mathematics is a living, breathing, changing discipline, currently experiencing explosive growth; we as mathematics faculty are trying to share these new ideas with our students.—Janet Caldwell
We need new thinking about "who will do science" and "why," thinking that may challenge college science teachers to grapple with issues they have not focused on before. These are how to recruit, teach, reward, and cultivate different kinds of students to science....

—Sheila Tobias

Preface

This second volume of Occasional Papers resumes our faculty's discussion of some of the pedagogical and content issues in higher education today. In particular, these six articles address some challenges and offer teaching suggestions in the fields of mathematics, computer science, and physics. The articles focus on teaching the sciences, but much of what the authors have to say about engaging our students and about the art of teaching is applicable to the practice of most disciplines.

Other than the broad topic of teaching the sciences, there was no special theme assigned to this issue. Faculty were simply encouraged to write about their recent academic projects, interests, and concerns. However, quite independent of each other, our contributors often struck the same chords. Among the common concerns expressed in the articles are (1) our country's urgent need to add to our pool of well trained scientists and mathematicians, (2) the equally urgent need for changing student attitudes toward the study of science and mathematics, and (3) the pressing demand for new approaches and methodologies in teaching these subjects. As Gary Itzkowitz points out—and his colleagues concur—when teaching the sciences, "the traditional lecture approach... is no longer viable."
Our faculty offer alternatives to enrich the traditional lecture method. Mike Berman discusses the advantages of computer conferencing, Karen Magee-Sauer advocates experiential and communal learning techniques, and Seth Bergmann reports his experiences with increased student participation.

Janet Caldwell provides an overview of changes in mathematics, and Ron Czochor and Gary Itzkowitz discuss two special initiatives on our campus—the introduction of the Contemporary Mathematics course and the BETA Project in Mathematics.

If you enjoy these insights into what our colleagues in other disciplines are doing, please consider contributing to a future issue of *Occasional Papers*. The more we know about our shared problems and goals, the more effective we are as advisors and educators. Exchanging ideas across the disciplines strengthens our collegial bond and our understanding of the College’s mission.

**Acknowledgements**

A special thanks to those who made *Occasional Papers* possible: Dean Minna Doskow, for her steadfast support; our able board of editors, Ginny Brown, Tom Kloskey, Mary Anne Palladino, and John Sooy; our authors, whose contributions are marked by clarity, timeliness, and insight; and Tom Kloskey again, for his expertise in layout and design.

Thanks also to George Neff and Jeff Otto, our fine artists; President James for his encouragement and for use of the Hollybush name; and Vice-President/Provost Harley Flack, Acting Deputy Provost Linda Ross, and the Write to Learn Program for financial support.

*Janice Poley*
General Editor
About the Author

Janet H. Caldwell received her doctorate in Mathematics Education from the University of Pennsylvania in 1977, after having completed a dual major in mathematics and French at Rice University.

She has been active in mathematics education at all levels, previously founding and directing McSiip (South Jersey Regional Mathematics, Computer, and Science Instructional Improvement Program) at Glassboro State College and currently serving as President of the Association of Mathematics Teachers of New Jersey.
Changing Views of Mathematics

Janet Caldwell

At the beginning of each course that I teach, I ask students to answer a few questions on an index card. In every course, one of those questions is, “What is mathematics?” I generally get about the same responses, no matter what the course title:

Math is numbers. Math is numbers and shapes. Math is figuring out answers. Math is adding, subtracting, multiplying, and dividing. Math is memorizing rules and procedures.

I’ve become intrigued by these fairly limited views of mathematics, and I’ve looked for published work on students’ views of mathematics. Here are a few of the comments I’ve found. From the Arithmetic Teacher, January 1988, in “Problem Solving and Mathematical Beliefs” by Martha L. Frank:

1. Mathematics is computation.
2. Mathematical problems should be quickly solved in a few steps.
3. The goal of doing mathematics is to obtain the right "answer"; the teacher always has it!
4. Mathematics is a set of facts, rules, and procedures; it is a "package" to be passively received.
5. Mathematics teachers are supposed to spend time explaining or "covering" material from the text, then verify that the students have received the knowledge by checking the students' answers. (32–34)

From the Mathematics Teacher, October 1989, in "Beliefs and Their Influence on Mathematical Performance," by Joe Garofolo:

1. Almost all mathematics problems can be solved by the direct application of the facts, rules, formulas, and procedures shown by the teacher or given by the text.
2. Mathematical thinking consists of being able to learn, remember, and apply facts, rules, formulas, and procedures.
3. Mathematics textbook exercises can be solved only by the methods presented in the book; moreover, such exercises must be solved by the methods presented in the section of the text in which they appear.
4. Only the mathematics to be tested is important and worth knowing.
5. Formulas are important, but an understanding of the derivations of such formulas is not useful or needed for anything.
6. Mathematics is created only by very prodigious and creative people; other people just try to learn what is handed down. (502–505)

Students seem to develop the view that mathematics is some mysterious domain that is accessible only to the select few. We encourage this view by using mathematics as a filtering mechanism—if you don't pass calculus, you can't graduate as a business major. Students believe that teachers
give rules for solving problems and exercises, which must be memorized and used. As early as second grade, they believe that these rules generally do not make any sense. They learn that if they do what they are told to do, they will get the right answers (at least most of the time), and then everyone will be happy.

No wonder my students seem to have so much difficulty in my classes! I ask them to actually think about what they are learning! I ask them to communicate about mathematics and reason about mathematics and connect what they are learning now to what they already know. I ask precalculus students to look at a number of graphs and find the patterns in their equations. I ask geometry students to use a computer program to collect data about the results of connecting the midpoints of a quadrilateral, make conjectures based on the data, and prove or disprove their conjectures.

Somehow, students' views of mathematics are very different from my own. I see mathematics as a much more active, analytical discipline. I have always loved mathematics because I didn't have to memorize things; new ideas just followed logically from concepts I already knew and understood. I love seeing the commonalities between seemingly disparate areas—how the matrix algebra I learned in high school is really related to vectors and the geometry of multi-dimensional spaces, how transformations can help students understand the graphs of functions, how the squares of numbers are just the areas of squares with sides of that length. I love to look for the patterns. I like exploring, wading into a problem and seeing "what if," trying out some hypotheses, looking for some generalizations, and trying to prove my results logically. The best definition I've ever seen for mathematics is one in Reshaping School Mathematics by the Mathematical Sciences Education Board: mathematics is "the language and science of patterns."

Changes are happening right now, however, in mathematics teaching and learning in the elementary and secondary grades as well as at the college and university levels—changes that
will help students view mathematics more positively, changes that will develop mathematical power and an I-can-figure-it-out attitude. The National Council of Teachers of Mathematics has issued a document called *Curriculum and Evaluation Standards for School Mathematics* that advocates a common core in mathematics for all students through the high school level, including algebra, geometry, data analysis, discrete mathematics, and optimization. These recommendations represent a major shift in emphasis from current mathematics programs, from a narrow computationally-oriented curriculum to a broader curriculum that includes experiences with several branches of mathematics. Instead of acquiring disparate pieces of knowledge on a rote basis, students must develop a connected conceptual framework, using knowledge as a tool for solving problems. Students must be actively involved in constructing mathematical ideas through exploring, investigating, discussing, and conjecturing. Problem solving must indeed be the central focus of instruction, with calculators used to lessen the computational load.

Perhaps the most relevant demonstration of these changes for us as state college faculty in New Jersey is the new High School Proficiency Test, required of all students for graduation from high school, beginning with the class of 1995. This test now requires students to use higher-order thinking skills, with questions from such areas as numerical operations, measurement and geometry, data analysis, patterns and relationships, and fundamentals of algebra. It is likely that this test will, by 1995, allow the use of calculators on at least part of the test, as will the College Board’s Scholastic Aptitude Test.

College mathematics is changing, too. No longer is Intermediate Algebra the single required mathematics course for graduation. In fact, this course is no longer appropriate for the vast majority of our students. Much more appropriate is a course such as Glassboro’s “Contemporary Mathematics” that shows students new developments in mathematics, that
highlights recurring themes in mathematics, and that broadens their understanding of what mathematics is. Precalculus and calculus curricula are being modified to meet the changing needs of our students and our society. Graphing calculators are being used in these classes to help students better understand the links between geometry and algebra. While calculators have long been used in all Glassboro mathematics classes (except developmental education), computers are also being used more frequently to help students explore mathematical situations. Mathematics is a living, breathing, changing discipline, currently experiencing explosive growth; we as mathematics faculty are trying to share these new ideas with our students.

Our society can not afford further generations of mathematically and scientifically illiterate citizens. The new automated workplace requires radically different skills of our college graduates. Business and industry leaders need employees who understand and can use statistics, communication skills, and problem solving. They need employees who can work in cooperative groups, can make decisions about production problems based on quantitative information, and can acquire new skills and behaviors on the job. What is needed is not disconnected rules, theorems, and techniques but rather the ability to think and reason, applying the power of mathematics automatically to problems that need to be solved. We must prepare our students to perceive patterns and solve unconventional problems.

Even faculty who do not teach mathematics convey their beliefs about mathematics to their students. If faculty are negative, so will the students be. If faculty view math as a requirement to be put off until the end of the college career since "it's not really very useful," students will echo faculty opinion. On the other hand, if faculty encourage students to take interesting, challenging mathematics classes, students will do so. If faculty show how mathematics is used in their own discipline and explain why students need to understand the mathematical concepts, it will motivate them to learn.
I wish that every student could view mathematics as did this little girl:

What I Learned in Math This Year: I learned that math is not just numbers. It is life. The reason I say that is because math can be made from anything, art, music, clothes, ice cream, even the ceiling. I could go on forever. Math is also thinking out things that confuse you. We need math. Without decimals, everybody would go bankrupt! I learned that it doesn’t matter how old you are or what grade you are in, you can learn anything if you really put your mind to it. If math is taught right, it is fun and easy to remember. (From 1989 NCTM Yearbook, p. 174.)
About the Author

Seth Bergmann is chairperson of the Computer Science Department at GSC and has been a member of the faculty since 1980. His main interests are programming languages, formal languages, compilers, and computer architecture. He has published in the area of computer algorithms.

Seth's undergraduate degree in Physics is from Rensselaer; he holds an M.S.E. in Computer Science from the University of Pennsylvania (and is A.B.D. at Penn). He has been a consultant to Univac, U. of P., Philadelphia Child Guidance Clinic, and other institutions. He has taught Computer Science at Oberlin College and at the University of Auckland in New Zealand.

Seth lives in Glassboro with his wife, Sue, and his children, Aaron, 10, and Sarah, 8. Sue is a social work administrator with the Family Counseling Service in Camden.
Audience Participation in Computer Science Courses

Seth Bergmann

Audience Participation, How and Why
Over the years it has become clear that students learn by actively participating in problem solution or discussion rather than by listening to a lecture. I believe this to be especially true in the mathematical sciences. In a lecture environment, the student tends to produce, at best, an autonomic copy of the lecture in his or her notebook. The information seems to enter through the eyes and ears, bypass the brain entirely, and go directly to the fingers of the writing hand.

To combat this problem, I find it necessary to force the students to take an active part in the presentation. I generally refer to this as audience participation, to borrow a term from television game shows. I start the process by stating a problem, beginning a computer program, beginning the construction of a data structure, or somehow getting things going. Once it has become clear that we will be producing a result through a series of logical steps, I turn it over to the students, who are called upon in the order in which they sit in the class, up and down the rows of seats. Each student gets an opportunity to fill in a small piece of the puzzle solution. If a student has trouble coming up with a response,
a little help is in order, and if this doesn’t work, I move on to the next student but always make sure an explanation is provided to help those who are struggling to keep up. When finished, I make it clear that the problem was solved by the students. I did not do it—they did—and if they can do it in class, they can do the homework, and they can solve the problems on the exam. This builds self-confidence and reduces fear of or intimidation by the difficult subject material.

The first time a class is confronted with audience participation, there is always some tension and nervousness. This tension can be lessened in the following ways. Before starting audience participation, I explain that the purpose of this exercise is not to embarrass students. They will not be graded or in any way judged on their responses. Its purpose is simply to make sure that they are thinking critically and logically in my class. Whenever a student comes up with a correct response, no matter how simple the problem, I commend the student. Also, I have found that it is important to use a casual or friendly tone of voice; speaking sternly or harshly only intimidates the students further. Occasional humor injected in the right way also helps.

When a student’s response is incorrect, I usually include it in the solution being constructed on the chalk board, responding mechanically to the student. It is inevitable that a contradiction will soon become obvious, and the hands go up or students call out the correct response. In this way students continue to think even when it is not their turn to respond.

Subject Matter for Audience Participation

In computer science there is no end to the topics which lend themselves to this kind of exposition. Anything which involves the construction of the solution to a problem through a series of logical steps will usually work, as long as there has been some preliminary explanation and the problem is not excessively difficult. For example, in teaching formal
languages in my Compiler Design class, the concepts of grammar and derivation tree are essential. I give the students the following grammar for arithmetic expressions involving only addition and multiplication:

1. $\text{Expr} \rightarrow \text{Expr} + \text{Term}$
2. $\text{Expr} \rightarrow \text{Term}$
3. $\text{Term} \rightarrow \text{Term} \ast \text{Factor}$
4. $\text{Term} \rightarrow \text{Factor}$
5. $\text{Factor} \rightarrow (\text{Expr})$
6. $\text{Factor} \rightarrow \text{constant}$

The problem is to construct a derivation tree for the expression $(2 + 3) \ast 4$ beginning with the syntactic type $\text{Expr}$ and applying the rules of the grammar until the leaves of the tree represent the desired expression, in which 2, 3, and 4 are examples of constant. This process is shown in figure 1.

```
Expr 1→ Expr 2→ Expr 4→ Expr
   /       /       /
  /Expr   /Expr   /Expr
 /       /       /
/Expr+Term  /Expr+Term  /Expr+Term
             /       /
            /       /
           /       /
          /Term   /Term   /Term
          |       |       |
          Factor Factor Factor
```

Figure 1

The students are asked which grammar rule to apply at a particular underlined point in the tree. The student's response is shown in front of the $\Rightarrow$ symbol. Note that the first response, rule 1, was incorrect and was subsequently corrected to rule 2 when starting over from the beginning, as shown in Figure 2 on the next two pages.
Figure 2
There are many other topics in computer science which are suitable for this kind of exposition. For example, when constructing a computer program, the instructor can present a general framework, flowchart, or pseudocode for the program and have the students complete the program with audience participation. For more complex programs, it often helps to do a trace of the program’s execution with audience participation. In a data structures course, after a program which builds a structure has been presented, such as a binary search tree, the construction of the tree for particular input values can be done with audience participation.

I am sure that this technique can be applied in other disciplines. For example, in mathematics the construction of a proof or the derivation of a formula can be outlined by the instructor and completed by the students. In chemistry the students could fill in a blank periodic table, and in biology
the students could label a blank anatomy chart. In general, any problem solution which involves a series of relatively small steps will be a likely candidate for audience participation.

**Tools for Audience Participation**

The simplest way to implement audience participation is with the chalk board in the classroom. As each student responds, the instructor fills in the response on the board (I like to move fairly quickly, and don’t like to wait for students to come to the board themselves, which can also be intimidating). The chemistry and biology charts referred to above are almost as simple. One way to do this is to put the blank chart on a transparency and project it on a white board (a blackboard doesn’t work quite as well) and fill in the students’ responses on the board.

One of my favorite tools is a computer with monitor or monitors that can be seen by the entire class. When developing a program, the students suggest ways of filling in the missing parts of the program, and I type them into the computer. This method always catches the students’ mistakes (as well as my own).

Finally, a course such as Computer Literacy, which is taught in a room with a computer for each student and an overhead display for the instructor’s computer, is designed for audience participation. In this case, all the students can respond simultaneously at their own stations. The instructor, as well as students who solve the problem quickly, can help those who have trouble.
About the Author

Ronald Czochor received his B.S. in Mathematics from Union College in Schenectady, NY, and both his Masters and his Ph.D. from North Carolina State University, where he studied biomathematics. His research interests include modelling the coevolution of hosts and their pathogens, chaos theory, and dynamical systems.

Ron's wife, Leslie, has a Ph.D. in Organic Chemistry and works at Noram Chemical Co. in Wilmington. Ron spends most of his free time playing with his daughters, Jennifer, four, and Rebecca, six months. He says the new toys are much better than when he was a child. When he is not playing with his children, he enjoys golf, tennis, theater, and travel.
Many students who come to Glassboro State College will take only one college mathematics course, and it will be our last opportunity to address an attitude toward mathematics that has been soured by three to four years of high school mathematics. In high school, students have taken mathematics courses that focus on drill and computation with the overriding goal of preparing them to take calculus in college. These courses are designed to prepare those students who already like mathematics to take more mathematics. They are not designed to win converts. Our new course at GSC is called Contemporary Mathematics, and it is designed to change attitudes and win converts.

Many recent reports have documented that our nation's technological superiority will not endure unless we improve our math and science education. We are certainly "A Nation at Risk," and to change this situation, we must be sure that future parents do not say to their children that mathematics was never easy nor useful for them. This sends a message that doing poorly in math is unimportant. Too many people in our society think of poor performance in mathematics as a badge of honor. It is disconcerting that many people I
meet see no problem in telling me how poor they were in mathematics. These people do not seem to think it is important to hide this ignorance because they do not see the value of mathematics. They all see the value of reading, so being unable to read is something many are ashamed of, but being unable to do mathematics is apparently not considered to be worthy of shame.

We designed this course to focus on these issues and to incorporate a number of goals:

1. To expand student understanding of and appreciation for contemporary mathematics and its uses
2. To develop student problem solving and critical thinking skills
3. To promote student understanding of the relationship between discrete and continuous mathematics
4. To improve student skills in applying computational and computer-related algorithms

These were the unstated goals:

1. To instill an appreciation of the value of mathematics in an increasingly technological society
2. To change an internalized view of mathematics perpetuated by secondary school mathematics (The second goal attempts to address this statement: "In my adult life, I have never needed to solve an equation, so I don't know why mathematics is valuable.")

The course we designed to meet these goals focuses on the modern applications of mathematics in our technological world. Students learn that they are living in the Golden Age of Mathematics and that more new mathematics is being discovered now than has been at any time in the past. They recognize that mathematics did not die with the ancient Greeks, and this is made clear by viewing videos that include interviews with mathematicians who are currently working
on problems in fields such as management science, statistics, health science, social science, and geometry, to name but a few. The computer and the way it has affected our thinking are also focuses of the course. That is why the course has as a goal the understanding of the distinction between discrete and continuous mathematics. It is only through this understanding that we can study the relationship between the computer and the human mind.

In designing the course, the first thing we did was to eliminate Intermediate Algebra as a prerequisite. Although this limited the amount of mathematics to be covered in the course, we reasoned that it would lessen the amount of hostility toward mathematics and that the trade-off was well worth it. We did not want students coming into Contemporary Math after having taken Intermediate Algebra because the college algebra course is an intense study of the same material that created a hatred of math in high school. Having math haters take algebra again would hinder our efforts to change their attitude about mathematics.

Next, we selected a relatively new textbook called For All Practical Purposes, that is quite unlike any other mathematics text. The book reads like a science text rather than the traditional math text that can often be made up of what seems to be just examples and exercises. This text requires our students to read carefully rather than scan the text for an appropriate example to help solve a problem. The text also requires changes in pedagogical techniques, which I will discuss after I present a topical outline of the course.

The course includes a study of the main topics of Statistics and Probability, Circuits and Networks, Real Numbers and Apportionment, and Geometry and Modelling. Under Statistics and Probability, topics include elementary sampling, experimental design, descriptive measures (including fitting data to the equation of a line), the mathematical theory of probability, and an overview of inference. Under Circuits and Networks, topics include applications to management science, such as scheduling, routing, and network design.
Under Real Numbers and Apportionment, topics include fair division (concerning both discrete and continuous structures), the structure of the real numbers, questions of rounding fractions in apportionment problems, and an example of an impossibility theorem. Finally, under Geometry and Modelling, topics include symmetry, patterns, tilings, and modelling growth and form for scale problems. Special attention is paid to the distinction between discrete and continuous mathematics, and a great deal of emphasis is placed on what an algorithm is and how it is used in problem solving.

This is a new type of mathematics course because of the way the textbook forces us to teach. Understanding the concepts discussed in each chapter is really much more important than merely computing the answers to exercises. Therefore, students must concentrate on reading the text for insight into concepts and knowledge of vocabulary. The course incorporates video tapes that enhance the use of the text and force the course to be taught in a discussion format that includes assignments in writing and oral communication. When I teach the course, I like to present it much like a biology course might be presented in which knowledge of vocabulary, concepts, and the correct application of concepts take precedence over the development of laboratory skills. I remember when I took a biology course, and we were asked to dissect an earthworm. I mangled the earthworm beyond identification. Still I knew and understood the earthworm because of my classroom study. I also recognized that I would never be a surgeon. When I look at the results of a Precalculus exam, I see a lot of mangled earthworms. Unfortunately, in Precalculus, I'm afraid the understanding of the concept isn't there, and that all that students get is the recognition that they will never be mathematicians.

Despite the discussion format, problem solving and computational skills are still very important parts of this course. This "laboratory skills" aspect of the course is still more heavily emphasized than it would be in any science
course; it simply is no longer the whole point of the course. Students find our text more difficult than other math texts because there are very few examples which can be translated to exercises. In fact, "exercises" is an inappropriate term in this case since the text provides problems that require students to make assumptions, to build a model, and to solve the problem.

Traditional topics, such as the equation of a line, the real numbers, algorithmic thinking, and elementary geometric shapes are still covered. It is only the context in which these traditional topics are studied that is different. For example, the equation of a line is studied as a linear model expressing the relationship between the day's mean temperature and the number of soft drinks sold at a baseball game. Also, the text discussion of the least squares method of fitting data to a line allows students to see how the simple mathematical object is used to model a real-world situation. The question of how to round off numbers is illuminated by an example of apportioning seats in the House of Representatives. How to schedule the turn-around time for an airplane if a number of sequential tasks must be completed or how to route garbage collection so that as few streets as possible have to be traveled twice are illustrations of algorithmic thinking, a main focus of the text. Finally, simple geometric shapes are studied in elementary scale problems, such as How high can we build a pyramidal-shaped mountain out of granite before it collapses under its own weight? or Will a scaled-up version of a model boat sink?

We have also designed the course so that we use state-of-the-art computer and video technology. The text has videos, which closely follow each chapter, produced by the Annenberg Project and the Consortium for Mathematics and Its Applications (COMAP). These videos not only use the best in visual demonstrations for presenting the mathematics, but also include interviews with current mathematicians who describe the work that they are doing
and its applications. The videos are viewed on the average of once a week for twenty minutes, after which the instructor can lead discussion or further develop the idea in the video with more sample problems.

Since much of modern mathematics relies on the computer as a tool, just as biology relies on a microscope, some of the mathematics discussed is also demonstrated with computer technology. For example, in studying the computation of the mean and median in elementary statistics, the concepts of stored programs, elementary programming languages, sorting, and relative efficiency of algorithms can be demonstrated through using the computer. Again, in the study of least squares fit to a line, computer demonstrations provide a visual of the data and superimpose the fitted line. Finally, when discussing the traveling salesman problem (i.e., find the shortest circuit among \( n \) cities), we can demonstrate the "brute force" method of testing all possible routes for a small number of cities and then a heuristic method such as the "nearest neighbor" method. We can show the difference in the time it takes to use each method and extrapolate to twenty-five cities. The "brute force" method would take a computer testing one million circuits per second a total of ten billion years to check each circuit.

We have been teaching this course at GSC for two years now and have run student evaluations. We have found that many of the course goals are being met to some degree. We have also found that although the use of the videos does not significantly affect the grades students receive, it does significantly improve their opinion of the text. Informal discussion with faculty who have taught the course indicates that the text is well received as interesting but difficult to teach from. Although there have been concerns about the students' attitudes in class, most faculty enjoy teaching this class more than teaching Precalculus or some other elementary mathematics course.
Since the students are often instrumental in the survival of a course, I thought I would end with their responses to the question, “What did you like about this course?”

“Taking this course really helped me overcome my fear of math.”

“I have been able to generalize the teachings into everyday situations.”

“It’s the best possible math course for a math hater like me.... This is the most useful math course.”

“I finally saw how you could use math in the real world.”

“The material covered was interesting, and I could apply it to everyday life. This usually doesn’t happen in any course.”

“Mathematics can be very interesting when it’s applied for practical purposes.”

“It isn’t Calculus, and it’s over.”
About the Author

A. Michael Berman received a B.A. in Economics from Pomona College and an M.S. in Computer Science from Rutgers University. He is currently completing his doctoral dissertation in Computer Science at Rutgers.

Michael has been teaching in the Computer Science Department at Glassboro State College since 1985. He has also served as a consultant to the Academic Computing Office. Previously he taught courses at Rutgers University and at Duke University.

Michael has been infatuated with computers for twenty-five years. His current research interests are data structures and algorithms.
Class Discussion by Computer: A Case Study

A. Michael Berman

Despite the broad and substantial impact of the computer on the Western World in recent years, the practical effect of the use of computers on the format of the typical college course has been nil. Even most Computer Science faculty continue to use the lecture model for most courses, although some courses do have a hands-on computing component, and some instructors bring the computer into the classroom for demonstrations. Outside of Computer Science programs, and courses that directly involve computer skills, such as computer-based graphics arts courses or computer-aided design, the use of computers has been minimal. In this paper I will discuss the use of computer-based class discussion.

The Course

In fall 1990 I taught Computers and Society for the first time. Computers and Society is an interdisciplinary course, designed by members of the Computer Science and Sociology Departments and currently offered by the Computer Science Department. The course looks at the application of computer and communications technology and considers its impact on social institutions such as the workplace, the family, and
society as a whole, as well as considering the ethical dimensions of computer use. About fifteen students completed the course, roughly half of them Computer Science majors, the others from departments as diverse as Life Science, Economics, and Secondary Education. Students were expected to have a background in computers at least equivalent to that provided by our Computer Literacy course. Computers and Society was built around reading and discussion. The primary text for the course was *Computers in Society*, a collection of readings from popular and academic sources, published by Annual Editions. The text was supplemented by additional articles chosen by the instructor or, in some cases, the students. For each class meeting, two of the students were assigned to present a summary of each reading and begin the discussion with two or three questions. Of course, every student was expected to read the materials in order to prepare for discussion. The discussions were supplemented by video tapes, demonstrations, lectures, and guests from other departments and off campus. In addition to these traditional course components, I thought it would be both useful and relevant to the course topics if the students were to participate in an ongoing discussion via the computer.

**Communications Software**

While there are many variations of the software available for individuals to use to communicate directly on the computer, most of it can be divided into two categories: electronic mail, or “e-mail” software, and conferencing software. E-mail software is based on the paradigm of the letter sent through the mail. An individual can compose and send a letter to one other individual, or send the same letter to a list of others. Conferencing software works more like a slow-motion conversation or a bulletin board: one individual “posts” or enters a message, and anyone else participating in the conference can read the message and post a follow-up message, or communicate privately with the poster via e-mail. While there is certainly substantial overlap between
these types of software, the e-mail paradigm is based on private, one-to-one communication; the conference is designed for group communication.

E-mail was available to, and used by, students in the course, but the purpose of this paper is to discuss the use of conferencing software to create an ongoing class discussion via the computer. We used a program called VAX Notes, running on our VAX with the VMS operating system. Students were able to access the computer via terminals in Robinson Hall, or in some cases by using home computers and modems.

Objectives
I had the following objectives in mind for computer conferencing:

1. The students would get practice in writing
2. The questions would stimulate the students to think about the issues raised by the course
3. The students would directly experience the impact of the computer on a social institution, in this case, the classroom
4. Students that, for social or personal reasons, find it difficult to speak out in the classroom setting, would have an alternative way to express their opinions

Assignments
Fifty percent of the student's grade in the course was based on class participation. The rest of the grade was based on a term paper. The syllabus stated that participation in the computer-based discussion would be a required component of class participation. In addition, it was pointed out that students who found it difficult to participate in the classroom would have the opportunity to improve their overall participation grade via the computer.

Since some of the students had never used the VAX before, and none had used VAX Notes, the first assignment was to
access the conference, look for a message from the instructor, and respond appropriately. The following message was posted:

Post a reply to this conference, answering the following questions:

1. What is your name?
2. Where were you born?
3. Have you ever had a pet? What was its name?
4. Have you bought any CDs, tapes, or records in the past six months? If so, what was your favorite?

Here are a couple of sample replies:

Hi! My name is C.B.,¹ and I'm a Senior economics major (math minor) here at GSC. I was born July 29, 1969, in Camden, NJ. I have a dog named Lance at home, but pets aren't allowed in Mansion Park so my parents take care of him. The last tapes I bought were the B-52's Cosmic Thing and the Cure's Disintegration album. My favorite groups are U2 and the Police.

My name is P.L.D. I was born in New Mexico. Yes, I did have a dog when I was very little and his name was Midnight. The latest tape that I have bought is "A Tribe Called Quest," which you may or may not have heard of.

Some of the replies were quite a bit longer than this. This assignment not only assured that the students got a chance to get familiar with VAX Notes, but also helped the participants to get to know each other. Following this initial assignment, some students began to communicate with each other via e-mail.

Of the half dozen or so topics posted for discussion during the semester, the one that resulted in the most interesting exchange was one directly related to the use of computer conferencing. The class had just read several papers on
Community and Social Participation, including a description of France’s national videotext system. France’s system, commonly known as the Minitel, was originally intended primarily for distributing information, e.g., providing an online telephone book. It has achieved both popularity and notoriety as a medium for interpersonal communication, some of it of a sexual nature. Inspired by the Minitel and our course discussions, I posted the following assignment:

Respond to the following:
It is a hoax to think that human interaction and communication can actually be improved through computer networking, as asserted in some of this week’s readings. People who interact through computers will become increasingly isolated and unable to cope with other human beings. The success of systems such as the French Minitel are a symptom of a sad and lonely world, not a cure for the alienation of modern society.

Here’s a sample of the replies to this posting:

Yes, I believe that it is a hoax. If face-to-face communication becomes less and less necessary, then nearly all the needs an individual requires to live could be received without ever leaving the home through the use of a computer network. The world would be filled with agoraphobics... everyone isolated and fearing the outside world. The society would not improve, it would fall. So turn off your computer and run into the street screaming!

I disagree that communication by computer networking will lessen human interaction. If anything, I think that it will help people who are shy and not as outgoing to communicate by computer with others, and eventually bring about an interest in meeting others. I also think that you would be missing out on life if you were to become isolated by computer networking.
There is nothing inherently wrong whatsoever with "networking." Communication of any type can lead to disastrous consequences, but one or the other type should not be singled out as being so much more possibly corrupting than all the rest.... Perhaps it is that we fear that there may be some less fortunate among us who will rise to obtain some notoriety when offered this powerful new forum for their ideas. Someone, after all, may try to step out of his society-assigned class-roles!... Well-adjusted, socially interactive individuals will prosper with the introduction of this far-reaching medium. No longer will individuals isolated by crippling handicaps and disease be so isolated—those who were once inhibited from social interaction due to fears of reprisal... will now be able to test out new ideas, and introduce them into areas where they are more effective....

People who do not want to communicate face to face will not. People who want to will. The computer can be a marvelous tool for someone who perhaps lacks the social skills or perhaps will be hindered in the social world. A disfigured person would be an extreme example but nonetheless a good one. People who have difficulty interacting socially will benefit greatly and will not become lonely but meet many new people that otherwise would be beyond their social reach.... I find it hard to believe that by expanding the number of people I come in contact with I will become isolated and unable to cope with other human beings. One must remember, even while I am typing this, I am talking NOT to a computer but to all the members of the class. And yet I'm becoming isolated...? I think not!!

I feel that computer networking is good for people who are not very outgoing in society. They have a chance to speak what is on their mind without the fear of public
harassment. I myself, who don’t like speaking out, love to communicate with other people through computers. Eventually, people who communicate a lot through computer terminals will start to speak out better in society.... they will become more confident in their ability to speak out.

A person that desperate to try to meet somebody by the computer is a hermit... a person like that should go see a shrink....

When I was in high school, I used to call a computer system called Diversi-Dial. It was a nine-person chat system. You would be able to call and talk to people all over the area.... Another user who was my age who went by the handle Astral Traveller was truly different. I never actually spoke to him, but on the screen he seemed like a cool, normal guy. He talked about sports and girls and computers like everyone else. He didn’t like people to know what he was hiding behind his IBM. He was handicapped and was in a wheelchair. The core users on the system became very close on screen, and some off.... Astral had an older sister who would chat with us once in a while. One day I went online on his system and the first thing on was a note from her. It said that Pieter, Astral, had passed away the night before. I don’t really know too much of his personal relationships, but I do know that except for his very close friends from the system, no one else was ever welcomed to his home. He hid behind his screen, never talking about his disability. Most of us never really had a chance to say goodbye. So I agree that too much computer interaction, and not enough personal is detrimental.

These are some of the other discussion questions used in the course:
Suppose you are on a committee for a labor union, responsible for negotiating workplace conditions. While you would prefer to outlaw “computer monitoring” of your employees, you have decided that it is inevitable. However, to protect your employees, you plan to attempt to achieve a set of written standards for the computer collection of employee performance data and for its interpretation. What would you wish to include in such a document?

Looking at it from the point of view of the company, would you be willing to accept such restrictions, and if so, which ones?

Many experiments and demonstrations are described in “The Media Lab” by Stuart Brand. Of those described, pick the one that:

1. Is most likely to be in common use by the year 2000;
2. If it were to be adopted would have the greatest impact on society.

(This could be the same experiment or two different ones.)

Explain and support your answers. For #2, discuss whether the impact is likely to be positive, negative, or some mix of the two, and why.

1. Considering all the functions of government (the military, tax collection, government regulation of industry, health and human services, etc.), make a list of things that you believe the government has a legitimate interest in keeping secret. For each one, explain in a sentence or two why each type of information ought to be kept secret.

2. Give an example of a type of information that you believe the government keeps secret that should be public information, and explain why you think so.

Analysis of Objectives
Overall, the use of computer conferencing met and exceeded my objectives:

Writing: The students did quite a bit of writing in the process of responding to the discussion questions. It should
be noted that the process of replying to a computer-based discussion leads to a different style of writing than the expository essay. Computer conference entries tend to be informal, conversational, and sometimes rambling. This tendency was reinforced by the VAX Notes software, which didn't make it easy to go back and rewrite an entry. Better software would help, but the conversational nature of computer conferencing will continue to encourage an informal style.

**Stimulating thought about the issues:** Based both on the quality of many of the entries, and on comments from the students, I do believe that computer conferencing was useful in encouraging students to think about the issues raised by the class. Instead of spending one three-hour session discussing the readings and the rest of the week working by themselves, the students had a chance to interact, discuss, debate, and think during the week.

**Experiencing the impact of computer conferencing:** The students certainly did experience it, although in retrospect I wish I had made this the last topic of conversation: How did the VAX Notes conference change the class for you?

**Participating in computer conferencing:** Some of the quietest students in class had interesting and valuable contributions to make on-line. Others were voluble in class and voluminous in their conference messages, and some seemed to find it difficult to find anything to say either in class or on the computer. Several students told me that they much preferred stating their ideas on the computer to presenting them in class.

**Student Reactions**

At my request, three of the students sent me their reactions to the computer conference. Here are some excerpts:

It gave me a chance to read others' thoughts, though I think it should be set up so you cannot read what others have said until you first comment.
I'm not an outgoing person, and I do like to think about what I'm going to say before blabbing. Given the option, I'd have taken the class using the Notes system alone. It was useful in that I was able to voice my full opinion without time constraints, and without argument or interruption.... I think it would've been better if all the topics that were going to be discussed were already in place. Instead of assigning particular Notes responses, maybe having the topics in place, and having each student post three messages under each topic would have served.

I really liked using Notes. I felt that it was sometimes easier to write your opinion than to speak it. I also enjoyed reading other people's responses (there were some pretty original ones). The opinion questions seemed to generate the most interest and “conversation.” The questions which did not seem to work as well were those which either required research or looking back to the readings....

Thoughts and Suggestions
Now that I've completed one semester using this system, I have the following thoughts and suggestions for instructors considering the use of computer conferencing:

1. Get the best software interface you can get. VAX Notes was kind of clunky, and at times I could tell the students were wrestling with it. This is an unnecessary distraction. I'll probably end up using the same software again, however, because it's adequate, and I don't have easy access to something better.

2. Short, opinion-based discussion questions work best. If the student has to leave the terminal to answer the question, it probably makes more sense to hand the questions out in class. (Of course, once more reference materials are available on-line, the range of questions that would work well on-line might be broader.)
3. Encourage the students to read each other’s replies so that a real discussion gets going rather than just a response to the instructor’s initial question. The students that took the time to read each other’s comments seemed to get the most out of the discussion. I may design some of the assignments next time to require students to read and react to each other.

4. I chose not to react directly to any of the students’ comments. Generally, I allowed the students to carry the discussion. This seemed to work well, and the students (at least some of them) seemed much freer in their comments on-line than in class.

Conclusion
Computer conferencing can be a valuable adjunct to a course. It can help those who have a hard time speaking out in class. It can provide writing practice. And it can reduce the isolation of class members outside the class meeting time. I would encourage instructors in any discussion-based course to experiment with computer conferencing.

Acknowledgements
I would like to thank my students for their valuable contributions both on- and off-line, and for their words, which make up a good chunk of this paper.

Notes
1 Students’ names are omitted. I have also corrected obvious typing errors in some of the entries.
3 In this context, “networking” refers to interpersonal communications tools such as e-mail and conferencing software.
4 A “chat system” is like a computerized party line—the users’ communications occur immediately as they type on their terminals. In computer terminology, this is called “real-time” communications.
Karen Magee-Sauer, an Assistant Professor in the Department of Physical Sciences, received her B.S. in Physics from the University of Virginia and her M.S. and Ph.D. in Physics from the University of Wisconsin.

Karen has published on the atmosphere of Halley’s comet and continues her planetary research at Glassboro. She is interested in physics education as well. She has received a grant from the Learning Assessment Center to evaluate learning in the introductory physics courses, an SBR grant to involve undergraduates in her research, and a grant from the NJ Institute for Collegiate Teaching and Learning to implement “experiential learning” in the Physics I course.

Karen’s husband Bryan is a research chemist studying polymers at the duPont Experimental Station in Wilmington. Their two-year-old daughter Kirsten and newborn daughter Bridget keep them busy.
Experiential and Community Learning in Science and Mathematics

Karen P. Magee-Sauer

A national colloquium sponsored by the Independent Colleges Office was held on February 4 and 5, 1991, at the National Academy of Sciences, in Washington, D.C. The topic was "Project Kaleidoscope: Strengthening Undergraduate Mathematics and Science Education." Project Kaleidoscope is an organization formed to offer a plan of action for those who want to make needed reforms in natural science and mathematics curricula at the undergraduate level. In their studies, members of Project Kaleidoscope found that gloomy predictions of the state of science education on the national level were on the mark. Among other things they found evidence for:

- An alarming low level of scientific and technological literacy in the general population
- A projected critical shortage of well-trained scientists, mathematicians, and engineers
- Severe inequities in the access of minorities and women to science and mathematics fields

The project studied successful undergraduate programs in
mathematics and science. At the colloquium, members of the project outlined the principles that guide strong programs in science and mathematics in the nation’s liberal arts colleges. The following list is a condensed version of “What Works”:

- Learning that is experiential, investigative, hands-on and steeped in research from the very start
- Learning that is meaningful in a personal way, makes connections with other fields, and has practical applications
- Learning which takes place in a community

The overall theme of the colloquium was, “O.K., here is what we have found to be successful. Let’s understand why these programs are successful and try and incorporate these methods and ideas into our own specific programs, and let’s start now.”

The above list of “What Works” applies to all areas of science and mathematics teaching. I went to this colloquium to help me learn about “What Works” in teaching introductory physics.

When I first came to Glassboro, I was naive. I believed that if I stated something in class, the students would not only understand the concept, but remember it; if I did an example on the board, then, of course, the students would be able to do problems themselves. To my dismay, this was not true. Some students failed physics despite their best efforts. Most students truly worked very hard in physics. So, if the students were genuinely trying, why weren’t they learning? I knew I had to make some changes in the way the course was presented, as well as encourage successful study habits.

One program that I started even before going to the Project Kaleidoscope colloquium was a workshop physics program. This program was based on research on peer learning by Dr. P. Uri Treisman. I set up weekly workshops to encourage students to work and study together. Students usually used
the workshops to work on homework assignments and study for exams. Many students formed study groups from the workshop that later met outside the workshop setting. Attendance in workshop was optional, but students who attended found that studying in a group was a more efficient, less frustrating method of studying. They didn't get hung up or stuck as often. As a result, students definitely improved their homework grades. Students who regularly attended workshops also developed a sense of "community" by working together and pooling their skills and knowledge.

The workshop environment was a small step to encourage community learning; however, I still needed to address my approach inside the classroom. Looking closer at "What Works," I realized that when I did an example in class, performed a demonstration, or explained a naturally occurring phenomenon, I was the one who was experiencing physics. The students were left out and were only observing physics. Thus, learning inside the classroom was not experiential, and it was not taking place in a community. Therefore, I knew that the traditional learning environment in my lectures needed a major overhaul. Experiential and community learning was emphasized only during physics laboratory and workshop, when students were supposed to be applying what they learned in lecture. However, since students hadn't grasped the material from lecture yet, the laboratories and workshops weren't as beneficial as they might have been.

When deciding what I should do about introducing experiential learning in the classroom, I wanted to see what other successful programs were doing. Project Kaleidoscope singled out the innovative approach developed, implemented, and tested at Dickinson College and Tufts University. This approach emphasizes experiential learning. Students acquire inquiry skills based on real experience.

The two programs at Dickinson and Tufts are very similar. The program at Dickinson replaces formal lectures with direct inquiry, using microcomputer-based laboratory (MBL) tools, appropriate curricular materials, and discussion with
peers. The role of the instructor is to help create the learning environment, to lead discussions, and to engage in Socratic dialogue with students. The program at Tufts continues to have formal lecture periods, but the lab incorporates MBL tools and appropriate curricular materials.

MBL tools are inexpensive probes connected to a Macintosh computer through an interface box. With appropriate software, the computer can perform instantaneous calculations or produce graphs. The tools are used to measure velocity, position, acceleration, force, sound pressure, temperature, and other physical quantities. In class, the students learn physics by actually doing physics.

The MBL tools are ideal to use when implementing experiential learning in the classroom. For example, when studying motion (velocity, acceleration, etc.), students use their own motion to help visualize the concepts of motion. The appropriate MBL tool gives them an instantaneous graph of their position, velocity, and acceleration. Since the Macintosh is menu-driven, students who do not have any knowledge about computers can begin to use the computers immediately. Here are some other advantages of using MBL tools to enhance experiential learning:

- They eliminate the time-consuming drudgery of data collection and display
- The data plotted is in real time so students get immediate feedback
- Since it is easy to display the data, it is easy to examine the consequences of changing the experimental conditions; thus many “what if” questions can be answered during a single period
- The tools are simple to use and set up

The programs at Dickinson and Tufts have been developed over the past five years or more. During these years, administrators did assessment tests to see if their new approach was better than the traditional lecture format. They
found that there is strong evidence for significantly improved learning and retention by students who used MBL tools over those who only attended formal lectures.

Other than the obvious advantage of improved learning and retention, there are other advantages to this experiential approach:

- Students acquire transferable computer skills
- Students learn to work together through peer discussions
- Learning is no longer passive. Students are forced to get involved in the discussion

What I plan to do here at Glassboro, beginning with the Physics I courses, is to:

- Continue organized workshops
- Incorporate MBL tools, appropriate curricular materials, and other "hands on" experiences into lecture time
- Strive to include activities which are meaningful and have practical applications

It is difficult to break the routine of the traditional lecture. However, even though some people manage to complete lecture science courses successfully, many potential competent scientists are weeded out. The threat of a shortage of scientists and engineers is a real one. Our methods in teaching science need to evolve to facilitate learning for all students.

The principles of "What Works" carry across the science and mathematics curricula. I have singled out innovative programs in physics, but members of Project Kaleidoscope highlighted many successful programs in biology, chemistry, earth science, and mathematics as well. A final report from Project Kaleidoscope, which will include topics discussed at the colloquium, is scheduled to be published in the summer of 1991. If you are interested in being put on the mailing list
for information about the Project Kaleidoscope report, send your name, title, institution, address, and phone number to:

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Notes

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Gary Itzkowitz is a graduate of the City College of N.Y. He did his graduate work at the University of California at Irvine, getting his Masters and Ph.D. there. At present he is Chairperson of the Department of Mathematics. His research interests include functional analysis, operator theory, and mathematics curriculum reform (particularly the introduction of appropriate technology into mathematics teaching.)

His interests include Tae Kwon Do (he is a third degree blackbelt) and Near Death Studies. He founded the Delaware Valley Chapter of the International Association for Near Death Studies in 1983 and is presently vice president of that organization.
The BETA Project: A Mathematical Perspective

Gary S. Itzkowitz

1. Introduction and Background

Last year, quite by accident, I picked up a newspaper and spotted an article about a U. C. Berkeley math professor named Uri Treisman. The idea that a newspaper would feel that a math professor was newsworthy intrigued me so much that I read the article. It pointed out that brilliant Black students at Berkeley flunked Calculus while White students didn’t, and told how Treisman investigated this situation, discovered the reasons, and devised a solution—so that now those Blacks that go through his program have a lower flunk rate than White students.

This article is about Treisman’s solution and our attempts to apply it at Glassboro State College. A number of synchronous events made our BETA project (Better Efforts Towards Achievement) a reality. First, our Dean, Minna Doskow, also read about and was inspired by Treisman. She then urged me to start a project right here at GSC. Next, the New Jersey Institute for Collegiate Teaching and Learning (NJICTL) sent me an invitation to hear Treisman speak. At the same moment that I was getting interested in Treisman’s work, so was Martin Finkelstein, Director of the
He brought Treisman in as a Scholar in Residence for New Jersey colleges for a whole year. Going to hear Treisman was inspiring for me. A charismatic speaker, he convinced me that there was something positive that I could do right here in the wilds of Glassboro.

What Treisman had discovered is that most Blacks and Hispanics came from a culture that was anti-academic. Students in this milieu could not speak to their friends about school or their problems in class. They had to do their school work in complete isolation. While this technique worked in high school, it was a formula for disaster in college. Treisman designed workshops to help these students learn how to study properly. His ideas came from watching the very successful Chinese group study habits and from Treisman's own Jewish background with traditional Talmudic group study techniques used in Yeshivas. He chose to integrate his workshop ideas into the calculus course because calculus was the gateway into all mathematics, science, and engineering programs. It was also the course that tended to be the great killer course for people going into the technical professions.

The fact that calculus was the killer stemmed from a peculiarity of the late 1950s. Historically, only about three-tenths of one percent of our high school graduates want to be mathematicians. Also historically, this small number of mathematicians was all that our society needed. Then, two things happened: Sputnik and the dawn of the computer age. All of a sudden, the number of math majors jumped to about four-and-a-half percent of the high school graduating class. The colleges were not prepared for this. The response was to use calculus to weed students out of the major. In the course, huge amounts of material were presented in a very uninteresting manner for the simple purpose of discouraging as many students as possible. Well, it worked. We are now back to our historical small numbers of budding mathematicians. Unfortunately, in this new technological age, we need great numbers of mathematicians. Treisman's
workshop was designed not only to help students survive a killer course like calculus, but to get them excited about mathematics.

At Treisman's Rutgers talk, he not only mentioned the success of these workshops but also the need to revise and decompress the syllabi of both the Calculus sequence and Pre-Calculus Math. As I thought about his talk, I realized that any successful program at GSC must have both elements: workshops and curriculum revision. I then set out to create such a program. I realized this ambitious project was going to take a great deal of effort, time, and money—and I didn't have any money. Again, synchronous events brought this project into existence.

Finkelstein called me shortly after Treisman's talk and asked if I would be willing to develop a workshop project at GSC. When I agreed, he immediately said that he could give me a few thousand dollars for seed money, provided my Dean would match his money. I knew Dean Doskow was enthusiastic about this idea, and it wasn't hard to get her financial commitment. She matched his money with six credits of released time, and Finkelstein formally gave me a grant of $2500. This got the ball rolling, but the amount of money was not enough to do what I contemplated. The next synchronous event occurred when I bumped into Jane Sullivan, who told me she was writing a grant proposal to the Department of Higher Education to use state monies to create a writing workshop using Treisman's ideas. As soon as I told her what I was trying to do, she invited me to join her in writing the proposal. She wrote most of the narrative, I contributed the math ideas, and Dolores Harris worked out the budget. In mid-August, DHE granted us $50,000 for our project. Now we had to scramble. We only had two weeks before school began, and everything had to be in place before then: the students, the faculty, the student mentors, and a place to meet!

The easiest part of the project was recruiting the faculty team. With a minimum of persuasion, Tom Osler and Evelyn
Weinstock agreed to head the curriculum revision. Ron Czochor and Marcus Wright agreed to run the workshop. Getting student mentors was a matter of approaching a few of our top majors; they were almost instantly excited. Finding a place to meet was a real headache. We needed a large room with small tables so that small groups of two to four students could work undisturbed. No such room existed. We needed to build this room by tearing out the wall between two offices, a delay that hurt us. We were not able to begin the workshops until the fourth week of the semester. For the math workshop, this meant losing sixty percent of our hastily recruited students.

II. Description of the Workshop

After being notified in mid-August that we had our grant, we immediately set to work finding students. Ollievita Williams in the EOF office helped us find qualified minority freshmen. We found one minority student ready for Calculus and twelve ready for Pre-Calculus Math. Since our grant was for developing methods for retention of minority students, it was obvious that we couldn't start the workshop with Calculus. We decided to begin where the students were—with Pre-Calculus Math in the fall and Calculus I in the spring.

We were constructing an elite program. This workshop was not for the purpose of tutoring the weakest students. In the workshop the students were going to be doing problems much harder than they would get for homework in the basic course. These students were required to sign up for regular sections of Pre-Calculus Math in addition to this non-credit workshop. We hoped that the work the students did in the workshop would help them to soar in their classwork. With this in mind, we created a letter of invitation to send to our possible recruits, telling them of this achievement program. Before sending the letter, we needed to find some qualified non-minority students, too. Experience at other schools had shown that an all-minority program, no matter how well
meaning, is automatically presumed to be a remedial program, which is precisely what these minority students did not need. After we found our qualified students (about thirty-five people), the letters went out. About seventeen accepted our invitation, even though no credit was involved. Unfortunately, the delay until the fourth week to begin the workshop caused many of our recruits to drop out. When we began, there were only about ten students left, of whom about six attended regularly. This small group became a tightly knit group that really worked hard and succeeded.

Getting student mentors was easy. Many of our math majors jumped at the chance to work with us. We wanted these student mentors to be a liaison between faculty and students. Since the mentors were closer in age to the students, we felt the students would be more willing to speak to the mentors and to ask them for help. Also, since we could not force the students to attend, we needed a mechanism to encourage them to come to the workshop sessions. If necessary, the mentors could call the students to remind them. They could even bring the problem sheets to their dorm rooms if students were ill. This system worked well, especially when combined with the free food we provided.

But we were offering a great deal more than free snacks. At each session the students were presented with both elementary and advanced problems—problems, in many cases, that they could not solve alone. Each would have to pool ideas with others to get a solution.

The food helped, too. In one instance, the students were working unsuccessfully, and individually, trying to solve a problem, when suddenly the pizza arrived. All work stopped and eating began. While eating and socializing, the students began to talk about the problem each was trying to solve. The next thing you knew, they figured out the solution—by working together!

The kinds of problems presented were determined by the course. Since Pre-Calculus Math deals with functions and their properties, graphics calculators turned out to be the
perfect tools to aid in the learning process. We managed to borrow enough TI-81 graphics calculators for all. The students loved this calculator and quickly became adept in its use. In several instances, with the aid of the calculator, they were able to pose questions to the faculty that couldn't be answered immediately. It became a learning experience for the faculty as well as the students.

By the time the fall semester had ended, Ron and Marcus felt the program was a relative success. The only thing they were unhappy about was the size of the group. They were determined to get additional recruits for the spring semester. Of the core group, all but one did extremely well in Pre-Calculus Math. One of the minority students even declared that he was going to change his major to mathematics.

Unfortunately, things did not go quite so smoothly in the spring. When we opened the workshop to additional students, we destroyed the close-knit fellowship of the original group. The addition of ten new students overwhelmed the old group identity. Most of the students in the spring never developed the group study techniques. Part of this problem was also due to the difficulty of scheduling. Many students just couldn't attend both meetings each week. Hence, they attempted each problem alone, without help. As a result, the faculty were disappointed, but for some strange reason the students weren't. They were still telling their friends about this "wonderful" math workshop they were attending.

I guess the conclusion is mixed. On the one hand, the students loved solving advanced problems, especially with graphics calculators. On the other hand, the faculty learned that if we are to teach students the group study techniques, we must strictly limit the number of additional students admitted in the middle of the year and get the students to arrange their schedules so that they can attend all sessions of the workshop. It would probably be a good idea to keep the number of additional students to less than half the original group.
III. The Curriculum Revision

As I have mentioned, the calculus course developed in response to a very rapid growth in demand. Now that the demand has fallen back to its historic low, we have a new problem. Half a century ago, our nation only needed a fraction of a percent of its population trained in mathematics, but in today’s high-tech world we need many, many more. Our challenge now is to develop a mathematics program that will attract people instead of turning them away. This challenge has been accepted by the mathematics profession. Many suggestions for attracting students have been put forward, but so far none has proved viable.

If we limit ourselves to Calculus, we can get an idea of what is involved. One suggestion is for a “lean” Calculus course. We have been throwing so much at the students so fast that we have lost sight of the fantastic beauty of the concepts. One proposal is to reduce both the complex Calculus syllabus and the size of the standard Calculus text. There is no agreement about what is to be removed. Another suggestion is to incorporate high-tech tools into the course, either graphics calculators or high powered math programs for computers like Mathematica, Derive, or MathCad. As Tom, Evelyn, and I were looking at these issues, we saw firsthand how much the workshop students loved the graphics calculator.

While checking the available experimental lean Calculus texts, we found nothing that seemed to suit our students. All the lean texts we saw were aimed at Princeton or M.I.T. students. These texts were also radical in their approach, while we were more oriented towards an evolutionary approach. For the present, we are not opting for radical change in the syllabus. Instead, we are moving to implement the use of graphics calculators. We looked at math software for computers but rejected this approach because of cost. There is no doubt that computer software is more sophisticated than the programming built into a graphics calculator, but a calculator can be carried easily into class
and can be just as easily taken home. This gives tremendous flexibility, and even though it may not be as sophisticated a solution, we discovered in the workshop that it can serve adequately. We have found that the use of graphics calculators actually “increases student participation, enthusiasm and ability to grasp concepts by a quantum leap,” according to a proposal submitted to the department by Tom Osler and Evelyn Weinstock.

The department has been talking about these ideas all year, and at our last official meeting on May 6, 1991, decided to make the momentous change of requiring the use of the TI-81 graphics calculator in all applicable courses. This will be implemented sequentially. In fall 1991 this calculator will be required in Pre-Calculus Math; in spring, it will be required in Calculus I and Calculus/Techniques and Applications (our business calculus course). In subsequent semesters other courses will begin using these nifty little tools.

This change means that all our faculty must now learn how to use these machines effectively in class. One of the lessons learned this year is that the traditional lecture approach in mathematics is no longer viable!

**IV. Results of the BETA Project**

We have already talked about the results of the curriculum revision portion of this project, namely, of not opting for a lean Calculus at present, of adopting the use of the graphics calculator in many courses, and of the necessity of retraining the faculty in this new approach. This by no means concludes our efforts. We must now figure out how best to integrate the use of appropriate technology in all our courses. Therefore, our curriculum revision efforts will continue into the foreseeable future. The department thought this was so important that it decided to use some of its released time for this purpose.

As far as the workshop is concerned, our question is: Have we accomplished our goals?
1. Did we show students how to study in groups?
2. Did we convince students they can enjoy and be excited by mathematics?
3. Did we attract a few good math majors, particularly minority students?
4. Did we get our faculty involved in these activities?

For goal number 1, our results were mixed. We definitely got the first group involved in group work but failed with the second group. We are encouraged enough by what happened that we intend to run this workshop again next year. Goal number 2 we feel was accomplished, just from the comments we've heard from the students. Goal number 3 was accomplished because one of the minority students decided at the end of the fall to declare as a math major. Goal number 4 was accomplished since not only did we get 5 people in a department of 16 directly involved, but several others on their own started exploring the use of software or calculators in their advanced math courses.

All in all, we had a very challenging and exciting year and are looking forward to the same in the future. The department now feels it has enough resources to keep this project going next year. Dr. Finkelstein at the NJICTL has promised us another $2500 if the Dean will match it again, and she has indicated her continuing willingness to support us. We will again apply for a DHE retention grant, but getting this grant will no longer be the sole determiner of whether or not this project continues. When we write our proposal to the DHE this year, we will be including several more departments in it.
About This Book

We composed this book on a Macintosh II with Connectix's Virtual 2.0, A Mac LC, and several Mac SEs and Pluses.

We used Claris MacWrite, Microsoft Word, Adobe TypeAlign and TypeManager, and Aldus PageMaker. The text faces are Janson Text and Janson Text Italic. The cover face is ITC Garamond. The arrowheads are Zapf Dingbats.

All the faces are from Adobe.

We printed proofs and page-readies on a Hewlett-Packard DeskWriter and an Apple Laserwriter II/NT.

Denby Graphics of Laurel Springs, New Jersey, printed and bound the finished copies.
About the Computer Artist

Jeff Otto, a fifth-year Assistant Professor of Illustration in the Art Department, has been creating graphic designs and illustrations since 1977. Besides being a visual artist, Jeff also composes and performs his own music and is digitally mixing and editing a new studio project, "Crazy Places."

When he's not in the studio, Jeff spends his time with his wife Jayne and daughters, Alyssa and Natalie. Last September, Jeff and Jayne moved the family to Glenside, PA, "a real Norman Rockwell kind of town."

Jeff is also an adjunct computer graphics instructor at Trenton State College and a member of the illustration faculty at The University of the Arts.

Jeff's computer graphics appear on pages 9, 17, and 45.