CALIFORNIA COMMUNITY COLLEGES 
AND 
PALOMAR 
COMMUNITY COLLEGE DISTRICT 

#91-0017
Fiscal Year: 1991-92

Project Title: Palomar College's Enhancing Mathematics Instruction Through Technology Project

Funding Category & Award: Grant = $13,149

Eligible Program: E --- Improvement of Trad. Instruction Prog

Project Category: Implementation Model

Project Product: Resource Materials

Project Topic #1: Curriculum Develop

Project Topic #2: Mathematics

Academic Subject: Mathematics

Project Director: Wendy Metzger & James Daniels, Associate Professors Mathematics

Project Supervisor: Diane Michael, Dean Science, Technology, Bus

Proposal Description:

College Algebra and Calculus curricula have been developed to include computer technology to improve students' abilities to understand and apply mathematical concepts while de-emphasizing the reliance on rote manipulation. Project activities included curricular research, site visits, conference attendance, textbook review and selection, preparation of course objectives, lesson plans, laboratory assignments and necessary revision for the two pilot courses taught in the Spring, 1992 semester.
Palomar Community College District

Palomar College’s Enhancing Mathematics Instruction through Technology Project

Palomar College’s Enhancing Mathematics Instruction Through Technology project will develop College Algebra and Calculus curricula using computer technology that improves students’ abilities to understand and apply mathematical concepts while de-emphasizing the reliance on rote manipulation that is typical of traditional mathematics instruction.

Educational Program or Service Addressed:
The proposed project addresses funding area 1(e), "Efforts to improve traditional instructional programs."

Problem Addressed:
The use of computer technology needs to be fully integrated into content and pedagogical methodology if it is to have any significant impact on what and how students learn. The specific problem which must be solved is "How do we enhance the teaching of our college-level mathematics courses at Palomar College with modern computational technology in a pedagogically sound way?" Staff release time is needed for curriculum development to solve this problem.

Population Served:
All students (approximately 1,800 at present) who enroll in a college-level mathematics course at Palomar College will ultimately be served. Initially, sixty students will be enrolled in the revised College Algebra and Calculus I courses. Students will represent a variety of academic majors, typically education, business, engineering, and the biological, physical, and social sciences.

Objectives:
The objectives of the project are to develop curricula that include computer technology in the teaching of College Algebra and Calculus I; to pilot test the two courses by teaching them during the spring semester of 1992; to make indicated revisions; and to disseminate the results through campus, local, state, and disciplinary networks.

Activities:
The two project co-directors will use 20 percent release time during the fall semester to research curricula, visit schools, and attend conferences; determine course objectives; review,
select, and order textbooks; and prepare lesson plans and laboratory assignments. During the spring semester the courses will be taught; materials will be revised as needed; a resource notebook will be created for each class; and dissemination activities will begin.

Dissemination:
Initially, project results will be disseminated on campus with a workshop for interested faculty. We will also share our results with other institutions through the presentation of results at selected conferences, and through the Chancellor’s Office and/or the Fund for Instructional Improvement as appropriate.

Budget:
Total program cost will be $18,380, of which $5,231 will be contributed by the college and $13,149 is being requested from FII.
1. Specific Educational Program Being Addressed

Specific Educational Program Being Addressed
This is a proposal for a curriculum development project which addresses the following specific educational program (California Educational Code, Article 7, Section 84381e)
*Efforts to improve traditional instructional programs

Background Information

Mathematics is the second largest department at Palomar College. Over 15% of the students enrolled at the college take classes in the Mathematics Department. Approximately half of those students are enrolled in remedial level courses and the rest are in college-level courses. The basic method of mathematics instruction employs a traditional lecture/demonstration methodology, except that those students enrolled in remedial level courses have available an alternate method of instruction via the Mathematics Learning Center.

The traditional approach to college-level mathematics instruction is predicated on the notion that students must master manipulation techniques in lower level courses so that they can gain understanding in more advanced courses.

Focusing on such manipulative skills often results in rote learning for students. The student memorizes the algorithm necessary to perform the manipulation without an understanding of the concept behind the manipulation. The long term outcomes of rote learning are poor retention of the manipulative skill (since once the rule is forgotten the student lacks the conceptual knowledge to reconstruct the rule), a lack of ability to apply the skill to related problems, a disconnected view of mathematics as isolated procedures with little or no interrelationship, and a lack of motivation to study mathematics since it appears to consist of memorizing a mass of facts that have no correlation with the student’s world.
Unfortunately, many students never get beyond the manipulation or computational stage during their lower level courses and hence are not well prepared for advanced courses in which they are supposed to understand the mathematics that they are using. This problem has long been recognized. More than twenty years ago a National Science Foundation conference on Computers in Undergraduate Education concluded that (underlining added for emphasis):

The availability of computers has created new challenges for curriculum development in mathematics. Specifically, the undergraduate mathematics curriculum must be changed to take account of new ways of solving old problems and the host of new problems which have arisen. Students will be enormously stimulated by the introduction of computing into the curriculum; for it will turn the all-too-often totally passive college experience into one of active participation. If the basic undergraduate mathematics courses are not appropriately modified to reflect the points of view which are associated with computer applications in mathematics, these courses will lose much of their relevance for the coming generation of college and university students.

Since that time, significant advances have been made in computer technology, yet computers are still not widely used in college-level mathematics courses at Palomar College.

Research has shown that technology is presently available which will allow students to focus on concepts and understanding rather than on variable manipulation and computation.

"Fey" contends that the mathematics curriculum must be changed to allow for the use of new software tools to teach students concepts and understanding rather than focusing on variable manipulation and computation; to focus attention on functions and relations as key concepts, and to emphasize applications and modeling. Kulik, Bangert, and Williams found in their research that technology, when used effectively, increases educational knowledge and retention while decreasing the time required to gain it. Other researchers have espoused the use of computer software as a valuable tool to assist students with translating and understanding concepts, as well as the manipulation of equations and calculations (Driscoll, Walton, Lowery, Gubser, and Bitter).

Consequently, we believe that the time has come to enhance the curriculum at Palomar College by incorporating computing technology into our college-level mathematics courses.

Most students enroll in mathematics courses not to become mathematicians but rather to fulfill some requirement for advanced study in some other discipline. More than any other academic discipline, mathematics is constrained to serve many masters. These diverse requirements are reflected in the stated student interests at Palomar College. In college-level pre-calculus and calculus courses surveyed recently, the following breakdown reflects those diverse student interests:

Student Interests
<table>
<thead>
<tr>
<th>Major or Vocational Area</th>
<th>Number of Students</th>
<th>Percent of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineering/Technical</td>
<td>108</td>
<td>29.5%</td>
</tr>
<tr>
<td>Liberal Arts/Social Science/Other</td>
<td>42</td>
<td>11.5%</td>
</tr>
<tr>
<td>Natural Science</td>
<td>40</td>
<td>10.9%</td>
</tr>
<tr>
<td>Business/Economics</td>
<td>31</td>
<td>8.5%</td>
</tr>
<tr>
<td>Computer Science</td>
<td>25</td>
<td>6.8%</td>
</tr>
<tr>
<td>Physical Science</td>
<td>14</td>
<td>3.8%</td>
</tr>
<tr>
<td>Medical/Dental/Pharmacy/etc</td>
<td>14</td>
<td>3.8%</td>
</tr>
<tr>
<td>Mathematics</td>
<td>12</td>
<td>3.3%</td>
</tr>
<tr>
<td>Teaching</td>
<td>9</td>
<td>2.5%</td>
</tr>
<tr>
<td>Accounting</td>
<td>6</td>
<td>1.6%</td>
</tr>
<tr>
<td>Undecided</td>
<td>65</td>
<td>17.8%</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>366</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

(Data collected by J. Daniels from calculus and college-level precalculus courses 1987-1990)

These figures substantiate (for Palomar College) the contention that students take mathematics for many different reasons. Therefore, we need to offer instruction that meets the needs of the majority of those students. It seems clear that for many of the areas shown, students do not need to develop great skill in paper-and-pencil computational methods. In a recent article, DeMana and Waits noted that

> The importance of, and need for, highly proficient skill in arithmetic and algebraic paper-and-pencil manipulation in the workplace has already been rendered nearly obsolete by technology. In this new decade we must help all students acquire the ability to make effective and appropriate use of technology. This ability entails a fundamental understanding of mathematical concepts and processes and their applications, along with critical thinking and reasoning skills in mathematics.\(^\text{11}\)

The proposed curriculum enhancements would serve our students’ needs for more relevant mathematics instruction.
2. Specific Problems Being Addressed

The Problem to be Addressed

Our mathematics courses need to be redesigned if they are to successfully incorporate computational technology. Because students can solve current textbook problems without the use of a computer and because most mathematics courses are already packed with content, simply using a computer without changing the course or adding a few new "computer" topics is not a reasonable solution to the problem of incorporating the use of technology into the mathematics curriculum. The use of technology needs to be fully integrated into content and pedagogical methodology if it is to have any significant impact on what and how students learn.

When do we begin to use technology in the mathematics classroom? Whenever and wherever the technology allows students to do mathematics more efficiently and effectively. When do we end our explorations of the use of technology in the mathematics classroom? Not when we have learned to do the old things a little bit faster but when we have found new ways to do mathematics and ways of doing new mathematics while using the technology to its fullest potential.

Technology can release students from tedious computation and allow the freedom to examine interesting "real-world" problems that are too difficult or time consuming to be done with paper and pencil. In short, computer technology can give students the mathematical power to engage in critical thinking and solve problems.

The specific problem which must be solved is "How do we enhance the teaching of our college-level mathematics courses at Palomar College with modern computational technology in a pedagogically sound way?" Therefore, the goals of this project are to:

a. Enhance the Palomar College mathematics curriculum by redesigning two college-level mathematics courses to take advantage of relevant computer technology
b. Demonstrate that the redesigned courses are feasible
3. Population To Be Served

Population to be Served
The population to be served will be the approximately 1800 students with a variety of goals who need and/or desire college-level mathematics courses at Palomar College. Sixty students will be involved in the revised courses offered in the Spring Semester 1992.
4. Objectives

Proposal objectives
The following objectives are necessary to accomplish the project goals:
1. Develop instructional strategies which integrate computer technology into the teaching of college-level mathematics courses.
2. Develop and prepare instructional materials for teaching a College Algebra and a Calculus I course using the strategies developed in objective 1.
3. Demonstrate that the two courses are "pedagogically sound" by teaching them during the spring semester of 1992.
4. Develop a resource notebook that can be used by all Mathematics Department instructors
5. Disseminate project results to Mathematics Department faculty and others
5. Workplan Narrative

Work statement
In order to redesign College Algebra and Calculus I to incorporate the use of computing technology we will first determine how to modify course content what to keep, what to add, what to eliminate. A few topics will be eliminated (such as repetitive manipulation and computation exercises which make students more efficient at low level skills) to make space for new topics that allow more emphasis on higher order cognitive skills, such as analyzing and synthesizing mathematical problems and concepts and communicating mathematical ideas effectively. We will then determine how to teach these topics using computer technology and make specific changes that will help the student to learn more effectively. Next, we will finalize selection of software that will best achieve these goals, and prepare lessons and activities that use the software to its best advantage. In addition, we will develop evaluation techniques and materials that require students to demonstrate their ability to use computers as a tool in mathematics. These preparations must be completed before the teaching of the courses begins. In Spring Semester 1992 we will teach the courses using the new design, making revisions as needed to improve course design.

The structure of the courses will be significantly altered by utilizing less lecture time and adding structured computer laboratory time. To use the computer as a mathematical tool, we must provide laboratory time as in any other science that requires the use of tools under supervision. Thus, we will require one hour of lab time per week for each course. This time will replace lecture time. This means that 20-33% of course content must be taught in the lab. New activities will be developed that are effective for laboratory learning, in which the students learn by investigation and discovery. More complex models of applied problems can be analyzed than can be done by hand, so alternate problem sets and activities will be developed that reflect the intelligent use of the power of computers. For example, computers make graphing much easier and allow the use of graphing as a tool in problem solving and in teaching of concepts. Since graphing is a significant portion of the content of both College Algebra and Calculus I, a new approach to graphing will be developed.

We will need the release time and travel financing provided by the grant in order to redesign the two courses to use technology in a pedagogically sound way.

A list of project objectives, dates of scheduled activities, and budget amounts per objective are shown in the attached Work Statement Form.

Feasibility of the project
The project is feasible because computer technology (both hardware and software) has advanced to the point where it is possible to teach students quickly the minimal skills necessary to effectively use the technology. In addition, considerable research has been accomplished in instructional methods using computer technology to teach mathematics courses. At Palomar College we currently have computers available in our Mathematics...
Learning Center, but they are primarily used in remedial level mathematics courses. Little use is being made of them in college-level mathematics courses.

The project co-directors are Wendy Metzger and James Daniels (resumes attached). Both have been full-time instructors in the Palomar College Mathematics Department for approximately 3 years and both have prior part-time teaching experience. Both have had significant work experience in applied mathematics and have been involved with applications of computer technology in industry or government. Both have undergraduate degrees in mathematics. Ms. Metzger specialized in mathematics education at the graduate level whereas Mr. Daniels specialized in applied mathematics. These two people have a particularly fortuitous combination of experience, training, and interest to apply to the project problem. Consequently, we have the necessary hardware, the right people, and the necessary motivation to carry out the proposed project. Thus the proposed project is entirely feasible at the present time.

In summary, the effective use of technology in the mathematics classroom requires significant modifications in course content and methods. If these changes are to occur at Palomar College, resources and effort beyond that normally available for class preparation are needed. Grant money for release time and travel would provide the resources; we are ready, willing and able to provide the effort.
6. Expected Outcomes

Expected

a. Project Objectives
   It is expected that, within the activity dates, the objectives of the project will be achieved. We will have in place two revised courses (College Algebra and Calculus I) at the end of the grant period. Each course will have a resource notebook for instructors to use when teaching the revised courses.

b. Eventual Impact
   Completion of the project activities will be a first step towards revising the college-level mathematics curriculum at Palomar College. The experience gained with computer enhancement will pave the way for eventual incorporation of computing technology into other courses in the curriculum, including the incorporation of graphing/programmable calculators if that option is desired at a later date. We expect that students who complete the revised courses will have a smoother transition from high schools, which already use technology in their mathematics curriculum, to universities and other four-year schools which also incorporate technology in their courses. Other possible outcomes are that these alternative courses will attract more students who intend to transfer to a four-year program.

c. Potential for Continued Support
   The potential for continued support of the project is excellent because we will have the computer lab facility, the software, two revised courses and the resource notebook available for continued use. In addition, our division dean is highly supportive of the integration of technology into the curriculum. Finally, we intend to seek support from the National Science Foundation to expand the project if additional funds are needed.

d. Potential for Adaptation to other Institutions
   There is potential for adaptation by other institutions because we intend to disseminate our results. Many community colleges have computer technology available for use in instruction and therefore have the need for instructional materials that make appropriate use of that technology.

Significance of the Project

Completion of the project would provide a sound basis for revising the Palomar College mathematics curriculum to incorporate technology. Considering the large number of students affected, the current reliance on traditional methods of mathematics instruction, and the obvious need for change, this project would certainly be a significant step forward for Palomar College.
7. Evaluation Plan

The Evaluation Plan

The evaluation plan consists of the following

a. Determination by the project directors and project supervisor that the necessary methods and materials to teach the courses in the spring are prepared during the fall semester.

b. Determination by the project directors and project supervisor that the two revised courses are successfully taught during the spring semester. The project directors will continuously monitor and evaluate the methods and materials used while teaching the courses. Methods and materials will be revised and refined as appropriate throughout the semester.

c. Preparation of instructor resource notebooks for the revised College Algebra and Calculus I courses.

We will make monthly reports during the academic year to the project supervisor detailing progress in order to verify the above determinations.
Dissemination plan
The project results and products will be shared with all interested instructors at Palomar College by providing a workshop presentation.

The project directors anticipate presenting the program results at the following professional meetings:
   a. California Mathematics Council (Spring 1992, an interim progress report)
   b. American Mathematics Association of Two-Year Colleges (Fall of 1992)
   c. International Conference on Technology in Collegiate Mathematics (Fall of 1992)
   d. California Mathematics Council (Spring 1993, a final project report)

Additionally, the project directors may also publish articles in local district newspapers and will cooperate with the Chancellor's Office in any desired dissemination effort carried out at that level.
References


7 Lowery, L T Equals in Computer Technology Berkeley University of California, 1986.

8 Gubser, L "National task force on educational technology " Techtrends, (31), 1986.


10 Mayes, op cit
