

FINAL REPORT TO ARIZONA BOARD OF REGENTS
Learner-Centered Education Grant Program
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Project Title: Developing and Promoting Learner-Centered Instruction Through Science and Engineering-Based Projects in Precalculus and Introductory Calculus

Principal Investigators: Marilyn Carlson, Steve Krause, Mike Oehrtman, Chell Roberts

Project Director: Marilyn Carlson
Director, CRESMET
Center for Research on Education in Science,
Mathematics, Engineering and Technology
PO Box 875006
Arizona State University
Tempe, AZ 85287-5006
(480) 965-6168
marilyn.carlson@asu.edu

Project Description:

In this project faculty and graduate students in the disciplines of mathematics, engineering, and science collaborated in developing 10 learner-centered modules for use in precalculus and beginning calculus, two large-enrollment undergraduate courses at our state's and nation's universities and colleges. Our curriculum development drew extensively from the body of relevant research, and benefited from the knowledge CRESMET researchers have gained in conducting two recently awarded NSF grants. Based on literature reviews and our NSF-sponsored research, each of the 10 modules was designed to engage students in the scientific process, while also promoting their understanding of the major concepts of calculus and effective uses of current technologies. In addition to the modules, we have also developed instructional support materials for teachers, problem-based activities for in-class group work, and take-home team design projects. The design projects, in particular, were created to promote students' further exploration and mathematical analysis of problematic situations. The group activities, team projects, and teacher support materials have provided research-based materials and tools to assist teachers in promoting a learner-centered instructional delivery for precalculus and beginning calculus courses. Our team developed the modules through multiple cycles of refinement, observing and documenting at each stage the materials' effectiveness in sparking students' curiosity and interest in learning scientific processes and applying mathematical concepts. We are now targeting other sources to fund a statewide workshop for the broad dissemination of the refined and validated modules. Significant portions these materials form the core of a new calculus sequence to be offered at ASU East beginning Fall 2005. Co-PI Oehrtman has submitted an NSF CAREER grant proposal to further develop and research calculus based courses using these materials.

Stated Goals and Project Outcomes

Goals	Outcomes
Develop 10 modules, five for precalculus classes and five for beginning calculus classes	<p>10 modules developed, tested, refined, and validated</p> <p>Content areas of the precalculus modules are 1) numerical methods and error analyses; 2) mathematical modeling; 3) radioactive decay; 4) relationships between distance, velocity, and acceleration; and 5) seasonal variation of daylight</p> <p>Content areas of the calculus modules are 1) kinematics; 2) inverse square law for gravitational force; 3) laminar fluid flow; 4) reaction rates; and 5) population dynamics</p>
Develop in support of the modules: instructional support materials for teachers, problem-based activities for group work, and take-home team design projects	Materials developed, tested, refined, and validated
Collect follow-up data in 2004–2005 academic year, drawn from testing of materials with students and teachers	Materials tested, instruments for data collection developed, data collected and analyzed, new knowledge formatively fed into curriculum development process
Show improvement in student learning of and interest in mathematics	As displayed in results from administration of the Precalculus Concept Assessment, the Views About Mathematics Survey, interviews, and classroom assessments, students of teachers who tested the materials showed gains in their understanding of the foundational concepts needed to succeed in calculus; their interest in and confidence in doing mathematics; and their facility in using problem-solving behaviors. Students met major portions of the benchmarks in qualitative measures defined in the hypothetical learning trajectories for the modules, and materials were revised in areas where students still had difficulties.

Work History of Project

In the fall and summer semesters of 2004, the project developed five modules to support precalculus-level students' understanding of the foundational concepts needed for success in beginning calculus and five modules to support beginning calculus students' understanding of the major conceptual strands of beginning calculus. We further adapted the modules to include additional science and engineering contexts during the spring semester of 2005. We piloted these modules with 26 students enrolled in a calculus workshop during fall 2004 and a more focused group of 9 students in spring 2005. Throughout, activities were videotaped, transcribed, and analyzed against the hypothetical learning trajectories to assess the modules' effectiveness in improving students' understandings, interest, and problem solving behaviors. In summer 2005 we have analyzed that data and refined the modules in accordance with our findings.

Accomplishments and Outcomes

Ten modules have been developed.

Marilyn Carlson piloted some of the precalculus modules in a graduate seminar for TAs of precalculus, and some materials were then piloted in one section of precalculus. Michael Oehrtman piloted the precalculus and calculus modules in three sections of calculus workshops. Interviews were conducted with six students from each section. Having analyzed the results, we find that they support that both the precalculus and the calculus modules are effective in promoting deeper understanding of the major mathematics conceptual strands in beginning calculus. Initially, the results also supported that the modules needed more refinement to assure that the prompts were providing sufficient scaffolding to promote mathematics, science, and engineering connections, student problem solving behaviors, and students' confidence in their mathematical abilities. The data revealed that specific activities required revisions. Once we made those revisions and added new prompts to scaffold success, student outcomes showed measurable improvement.

Problems or Issues

We originally delayed piloting of the precalculus modules in the university precalculus classes until spring 2005 because we had the opportunity to work with instructors of the precalculus courses in fall 2004. To pilot with precalculus students, we offered an additional 1-credit-hour course for students enrolled in precalculus, with our modules serving as the course's main curriculum.

Date of Completion:

July 31, 2005