

**UNDERGRADUATE COURSE AND CURRICULUM
DEVELOPMENT PROGRAM**

AWARDS: 1995

**Division of Undergraduate Education (DUE)
Directorate for Education and Human Resources (EHR)**

NATIONAL SCIENCE FOUNDATION

DIVISION OF UNDERGRADUATE EDUCATION

Undergraduate Course and Curriculum Development Program 1995 Awards

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Foreword

The National Science Foundation's (NSF) Directorate for Education and Human Resources (EHR) is responsible for providing national leadership and support for enhancing the quality of education in science, mathematics, engineering, and technology at all levels of the educational system. Within EHR, the Division of Undergraduate Education focuses on ensuring that the best possible undergraduate education is provided to meet the Nation's need for high-quality scientists, engineers, mathematicians, and technologists, dedicated and able teachers of pre-college science and mathematics, and scientifically literate citizens.

The *Undergraduate Course and Curriculum Development (CCD) Program* supports the development of courses in all disciplines within the Foundation's mission. Initially, the CCD program has emphasized reform of the crucial lower-division and introductory courses. The enormous interest of the academic community during the first five years of the interdisciplinary program clearly reflects a national need and underscores NSF's important leadership role at the undergraduate level.

The systemic initiative *Mathematical Sciences and Their Applications Throughout the Curriculum* builds on the reform that has taken place through the Calculus Program and other NSF undergraduate programs. Its goal is the development of institutional models with national implications that demonstrate how the mathematical sciences can be integrated into other disciplines and how instruction in the mathematical sciences can be improved through incorporation of other disciplinary perspectives.

Another initiative, *Systemic Changes in the Undergraduate Chemistry Curriculum*, is attempting to enhance the learning and appreciation of science through significant changes in chemistry instruction. NSF is supporting projects that are designed to make fundamental changes in the role of chemistry within the institution, including better integration with curricula in related disciplines such as biology, physics, geology, materials science, engineering, computer science, and mathematics.

The projects described in this book received awards in FY 1995, and were selected for their creativity, scientific and educational quality, and potential for utility at multiple institutions and national impact. We are proud of these projects and hope that they will be of interest to science, mathematics, and engineering faculty at all U.S. colleges and universities. Building on the courses and curricula developed in these projects, institutions can work toward achieving comprehensive, institution-wide reform of undergraduate education.

Luther Williams
Assistant Director
Directorate for Education and Human Resources

NATIONAL SCIENCE FOUNDATION

UNDERGRADUATE COURSE AND CURRICULUM DEVELOPMENT

INTRODUCTION

Overview

The purpose of the National Science Foundation's Course and Curriculum Development (CCD) program is to improve the quality of undergraduate courses and curricula in science, mathematics, engineering, and technology (SMET). The program also seeks to encourage a greater number of talented faculty to devote creative energy to improving learning by undergraduates in the Nation's classrooms and laboratories. In FY 1995, the CCD program granted awards to 126 new projects from 39 states and the District of Columbia. Support was based on the recommendations of notably qualified panelists. Projects receiving awards are those that address CCD objectives in the areas of:

Course and Curriculum Development—98 Awards

Leadership in Laboratory Development—8 Awards

Systemic Changes in the Chemistry Curriculum—7 Awards

Mathematical Sciences and Their Applications Throughout the Curriculum—3 Awards

Science and Humanities: Integrating Undergraduate Education—10 Awards

Total award amounts include funding from the Directorate for Education and Human Resources, other NSF research directorates, and other agencies. Common themes in these awards are the creation of modules and the use of new technology to develop innovative pedagogical techniques, and the design of stimulating curricula intended to attract, encourage, and retain groups currently underrepresented in SMET enrollment. Awarded projects are expected to produce course and curriculum materials that will be of broad national interest and intended for wide dissemination. While the majority of program funds support proposals for introductory-level courses, curricula and laboratories, the CCD program also supports proposals intended to benefit upper-level students. This summary highlights representative examples of the newly awarded projects, while the attached awards list includes previous CCD projects that received additional funding in FY 1995.

CCD Program Priorities

The current priorities of the CCD program are two-fold: 1) to promote the development of multidisciplinary and interdisciplinary courses that will better prepare students for the science- and technology-based environment of the future; and 2) to encourage SMET faculty to take leadership roles in developing educational experiences

that enhance the competence of prospective teachers and encourage students to pursue teaching careers.

Course and Curriculum Development Projects

Several CCD awards in FY 95 were made to support projects that promote the development of inter- or multidisciplinary courses. As examples of such courses, Yale University (CT) is designing graphics software and instructional materials for three fractal geometry courses, including an introductory pre-calculus course emphasizing connections to art, economics, music, and philosophy. The University of California-Los Angeles (CA) is developing an innovative laboratory format that explores the interrelationships of atmospheric science, biology, chemistry, mathematics, and physics. Hampshire College (MA) is conducting a conference to bring together faculty from a variety of disciplines and diverse institutions to document successful approaches in the teaching of science in which students are active participants. City University of New York (CUNY)-Manhattan (NY) is adding chemistry, computer science, and physics to its mathematics courses to emphasize the interrelationship of scientific disciplines. Carnegie Mellon University (PA) is integrating environmental issues into introductory engineering courses to provide students with exposure to environmental concerns and problem-solving methods for their respective engineering disciplines. Brown University (RI) is developing teaching and research tools on human behavior, including communication, speech and gesture, writing and language acquisition.

A number of the 1995 awards propose to develop educational experiences that enhance the competence of prospective teachers in science and mathematics and encourage students to pursue careers in teaching. The University of Florida (FL) is offering a course for future elementary teachers focusing on current engineering topics, presented in a manner that can later be used in the classroom. In its *Science as Constructive Inquiry* project, CUNY-Brooklyn (NY) is developing a science preparation sequence for urban pre-service elementary teachers designed and piloted by faculty from biology, chemistry, geology, and physics. A project led by Dickinson College (PA) is offering three introductory physics curricula that promote scientific literacy and motivate students through the mastery of concepts, investigative skills, and modeling techniques; workshops for high school and college-level instructors, public talks, site visits and publications are included for the dissemination of project materials.

The creation of instructional modules is included in a number of the current CCD projects. The College of Du Page (IL) is developing laboratory modules that reflect the latest innovations and theoretical applications from practitioners of atmospheric science and meteorology. An introductory program at Columbia University (NY) will examine quantitatively human nature from biological, social, and information processing perspectives. This modular program provides the infrastructure for a core curriculum in science that emphasizes student participation in data collection and analysis. The American Association of Geographers (DC) is infusing curricula with topics in global change that include faculty and pedagogical experts in the development of activity-based modules on global change, with particular reference to human motivation and responses. Iowa State University (IA) is collaborating with 15 community colleges, three public universities and four private colleges in using instrumentation-oriented modular instructional

resources to emphasize conceptual thinking, interactive multimedia and exploratory laboratory experiments. Similarly, the New Jersey Institute of Technology (NJ) is leading a consortium of 19 community colleges in developing model and training curricula for manufacturing systems.

Several institutions propose the use of technology to enhance the learning experience for their undergraduate students. Four university units at the University of Georgia (GA) are collaborating on the implementation of a Geographic Information System and an interactive multimedia program to guide students in long-term ecological studies, including the testing of formal hypotheses based on collected field data. The University of Utah (UT) leads a group using computer-based laboratories to illuminate scientific principles and provide computational solutions to real-world problems in science and engineering. Massachusetts Institute of Technology (MA) is designing educational software for undergraduates enrolled in cellular biophysics courses. A group led by Duke University (NC) is developing a comprehensive, introductory computer science course, simulating the levels of processing in an idealized machine. Washington University (MO) is designing computer-graphics color animation to illustrate the geological processes contributing to the propagation of seismic waves, earthquakes, and plate tectonics. A consortium based at Virginia Polytechnic Institute and State University (VA) is developing a novel laboratory approach to instruct engineers in introductory statistics, emphasizing problem-solving, conceptual understanding, and writing skills.

South Seattle Community College (WA) is working in cooperation with Boeing Company, Eldec Corporation, Clover Park Technical College and 12 other organizations to develop a process for determining specific workplace standards for manufacturing education and training. San Jose State (CA) is creating an education and training center for mechatronic systems that involves the development of new courses and laboratories in mechatronic engineering, as well as revitalizing the extant curriculum. Sonoma State University (CA) is developing a networked simulation of the international financial system that allows groups of students to interact with each other. Because outcomes depend on their combined decisions, it simulates the dynamics of real-world economic systems.

Several awarded projects are oriented towards specific populations of students. In a project that targets large, general education courses for non-science majors, Radford University (VA) is using computer-aided learning modules to teach fundamental concepts of geology. The University of North Dakota (ND) is addressing the needs and expectations of paraprofessional engineering students by offering an enhanced curriculum for adult learners based in industry. The Biological Sciences Curriculum Study (CO) is providing an integrated and coherent approach to biological literacy for students enrolled in community colleges. By incorporating the evaluations of students in this project's design, the instructional materials will also be of interest to future K-12 teachers. Central Texas College (TX) is providing challenging, entry-level community college courses to improve the success of groups underrepresented in SMET, including African Americans, Hispanics, and women. The project also includes a workshop for science teachers from area high schools. Rutgers University (NJ) is also encouraging its large minority student population through outreach efforts in its introductory physics laboratory course. The University of Southwestern Louisiana (LA) is targeting the emerging discipline of computer information science with an ambitious project that provides detailed curriculum guidelines, laboratory materials, original teaching and learning paradigms, and methodology for dealing with complex information systems.

Leadership in Laboratory Development(LD)

Leadership in Laboratory Development (LLD) projects are those that fundamentally reform and improve experiences in the laboratory, and that have the potential to serve as models nationally. Awardees include the University of Massachusetts-Amherst (MA), which is leading the development of a computer laboratory for the teaching of fundamental molecular genetics. *MOLGENT* exploits advances in technology to provide multimedia instruction more thoroughly and effectively than traditional lectures or textbooks. The University of Louisville (KY) is developing a laboratory course in microfabrication, providing an introduction of this versatile and powerful technology to a broad student audience. The University of North Carolina (NC) received an award to lead in the creation of a library of interactive, experimental workbooks in mathematics, to be provided free of charge over the Internet.

Systemic Changes in the Chemistry Curriculum

Systemic Changes in the Chemistry Curriculum is one of two initiatives that encourage institutions to reexamine the roles of disciplinary departments within the instructional program as a whole. Awards in FY 95 include the Modular Chemistry Consortium led by the University of California-Berkeley (CA). In collaboration with 17 other two- and four-year institutions and universities, they are developing new curricula and methods intended to enhance the learning of chemistry and retention of this knowledge for all college graduates. The program uses modules to present chemistry in the context of real-world problems; the scientific skills learned by students can be applied to inform decisions throughout their lives. In collaboration with this project, the *ChemLinks Coalition* centered at Beloit College (WI) is developing instructional materials and course modules using active, cooperative methods of learning chemistry, including a model for students preparing for careers in teaching. Collaborators on the project include liberal arts colleges (Beloit, Carleton, Colorado, Grinnell, Hope, Kalamazoo, Knox, Lawrence, Macalester, Rhodes, Spelman, St. Olaf, Wooster), two-year colleges involved in the Advanced Technology Environmental Education Center, as well as research universities (Chicago, Washington-St. Louis). Heading a consortium that includes 10 four-year and community colleges and the Universities of Pennsylvania, Pittsburgh, and Rochester, the *Workshop Chemistry* project based at CUNY City College (NY) will use small group, student-led workshops to complement chemistry lecture and laboratory components, with an emphasis on skills in problem-solving, communication and teamwork. In the *New Traditions* project, the University of Wisconsin-Madison (WI) is also leading a consortium of public and private institutions to establish new learning communities, curricula, materials, and methods for student learning of chemistry. All of the projects include specific components emphasizing pre-service teacher training and the education of technology specialists.

Mathematical Sciences and Their Applications Throughout the Curriculum

Mathematical Sciences and Their Applications Throughout the Curriculum supports projects that promote comprehensive institutional changes by integrating the mathematical sciences into other disciplines, and that improve instruction in the mathematical sciences by incorporating perspectives from other disciplines. Integration of mathematics with courses in architecture, art, biology, computer science, geology, economics, engineering, literature, medicine, music, philosophy, physics, and social science is the goal of a consortium led by Dartmouth College (NH), which includes the cooperation and participation of approximately 40 diverse two- and four-year colleges and universities. Software, on-line materials, and videotapes are among the resource materials to be developed, along with a series of intensive summer workshops. Rensselaer Polytechnic Institute (NY), in collaboration with Central State University, the University of Delaware, Hudson Valley Community College, the University of Maryland, Siena College, and Virginia Polytechnic Institute is focusing on linkages between mathematics and disciplines in science and engineering. The University of Pennsylvania (PA) leads a consortium including the Community College of Philadelphia, Polytechnic University, Villanova University, the Society of Industrial and Applied Mathematics, and public schools. This project promotes faculty responsibility across disciplines for effective SMET education, and integrates research and realistic applications into the undergraduate experience.

Science and Humanities: Integrating Undergraduate Education

The *Science and Humanities* program, jointly supported by NSF and the National Endowment for the Humanities, promotes the development of courses and curricula that link meaningfully the study of science and the humanities. The 1995 award recipients include Mt. Holyoke (MA) for its *Mathematics Across the Curriculum* project, which introduces students to the application of mathematical ideas and reasoning to introductory humanities courses in an engaging and non-threatening context. Southwest Texas State University (TX) is providing a summer institute for college faculty, transcending traditional disciplinary boundaries and emphasizing an interdisciplinary content in its multi-faceted study of the physical, historical, environmental, and cultural aspects of the Southwest United States.