## The Unity of Science: A Year-Long, Exploration-Oriented Interdisciplinary Science Course

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FY 1995 $ 150,000
Interdisciplinary

The goal of this course is to develop an interdisciplinary introductory science course for first-year college students that emphasizes the methods and relevance of scientific inquiry. Target students are primarily those students that do not intend to major in a science. The course content includes interdisciplinary topics of broad interest in logical sequences. It begins, for example, with color vision (physiology, perception, optics, spectroscopy), autumn foliage (isolation of chlorophyll, photosynthesis, light as energy), and the origin of oxygen-rich atmosphere (respiration, flow of energy through biosphere, ecosystems). This theme (light, energy, and matter) then leads the students through topics in astronomy, physics, chemistry, geology, and biology, all in context and without traditional discipline boundaries. Laboratory demonstrations and exercises are exploration-driven with students actively participating in defining the questions that are asked and how we look for answers. In the last half of the year, small groups of students carry out self-directed research projects and present their results to the class. Three faculty from different disciplines are teaching the course through lectures to the entire class (approximately one-third of the meetings) and in smaller discussion groups (two-thirds of the meetings). Course content is able to evolve and change depending on the faculty involved in a given year. A lab director facilitates weekly lab exercises, and senior students from all disciplines serve as teaching assistants and role models. Students are graded by the quality of exploration reports, projects, and personal journals. There are no timed exams.

## Linguistic Semantics as Science

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DUE-9150417
FY 1991 $ 74,002
FY 1992 $ 115,728
FY 1993 $ 32,667
FY 1995 $ 15, 025
Interdisciplinary

The goal of this project is to create a sophomore-level undergraduate course introducing students from a wide variety of backgrounds to the principles and results of linguistic semantics. The heart of this course is a software "workbook" that presents the material in an interactive, graphic environment. The course and workbook address various aspects of meaning, including its relation to word and sentence form (morphology and syntax), its relation to systems of mental representation (cognition), and the interaction between meaning and use. The goals of the course are to reveal to students the complex internal system of rules and principles that underlie our abilities as native language speakers to let them experience some of the intellectual excitement that comes with discovering such principles and struggling to formulate them in a precise way, and to

encourage them to explore the computer as a model of how we, as human beings, think and understand. The results of this work are of significant value in introducing undergraduates to the principles of scientific reasoning, in reaching students not otherwise considering science majors or extensive science electives, and in helping to foster interest and interdisciplinary exploration in the cognitive sciences.

### Visualization Technologies in Environmental Curricula (VTEC)

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DUE-9354599
FY 1994 $ 246,980
FY 1995 $ 153,411
Interdisciplinary

The Visualization Technologies in Environmental Curricula (VTEC) Project is a large-scale partnership effort among: Sigma Xi, the Scientific Research Society; North Carolina State University; Duke University; the University of North Carolina at Chapel Hill; The North Carolina Supercomputing Center; North Carolina Central University; The North Carolina System of Community Colleges; industry; government; faculty; and student consultants. VTEC is a two-year project to develop, demonstrate, and evaluate an interdisciplinary, problem-oriented, team-based, environmental case study development strategy involving faculty, undergraduate students, and consultants from industry, government, and supercomputing centers. The project employs environmental curriculum case studies and instructional materials that effectively integrate the power of computer networking and visualization technology in enhancing understanding of scientific concepts and their interrelationship with other disciplines in the solution of complex environmental issues. These visualization-enhanced case studies are intended to increase environmental and scientific literacy and improve undergraduate student attitudes toward science and technology careers, particularly among women and underrepresented minorities. Comprehensive, project-driven computer visualization and networking skills development at the North Carolina Supercomputing Center enable excellence in curriculum development for collaborators from participating universities and community colleges.

### A New Approach to Earth and Environmental Science Undergraduate Instruction

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DUE-9455688
FY 1995 $ 150,000
Interdisciplinary

Columbia's Department of Geological Sciences and Barnard's Department of Environmental Science are developing a new curriculum in Earth and Environmental Science that builds on the intellectual and information resources of Columbia, Barnard, Teachers College, Lamont-Doherty Earth Observatory and the NASA/Goddard Institute for Space Studies (GISS). This two-year project involves design of a multidisciplinary introductory core curriculum, for both

geology and environmental science majors. This three semester core, serving both Barnard and Columbia, focuses on three interacting global systems: the lithosphere, the climate system, and the biosphere. Women form a key target audience of this enhanced curriculum, through merging of the Barnard introductory sequence with that of Columbia. The core incorporates new technologies for accessing, analyzing and transmitting information, thus shortening the information path between research scientist and undergraduate. An electronic library containing data, text, models, graphics and analytical tools is being developed. Through this electronic library, students can explore features of the three systems and processes that operate within and among them. The design team, brought together from within the Columbia community to develop and implement the curricular revisions, engages a wide variety of scientists and educators in the process.

## Discovery - Based CAI Fundamentals of Science Course Focused on Relationship Thinking, History of Science, and Math Applications

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DUE-9455599
FY 1995 $ 132,905
Interdisciplinary

The project being developed is meeting a demonstrated need to provide an interesting, challenging, entry-level science course in community colleges to improve the success rates of educationally-disadvantaged students. Many students are under-prepared for mastering concepts in college-level biological and physical sciences because they do not understand principles which use relationship thinking. The objective is to develop an interdisciplinary, experiment-based FUNdamentals of Science course with a history-of-science theme and discovery methods to investigate measurement, density, gas laws, electric circuits, and light, including lasers. Relationship thinking and skills to use mathematics as a tool are being developed by having students use a computer program to create graphs of relationships from data. The program targets the many new and returning students who function at approximately the intermediate algebra level. This group includes especially women, African-Americans, and Hispanics who need a successful experience in their introduction to the sciences. Three four-year college professionals in undergraduate science education have agreed to serve as advisors for this project. Student progress is being tracked and analyzed. Detailed explanations for integrating experiments and computers into the entry-level course are being developed and disseminated. A workshop (Innovations in Science Teaching) to present the methodology and materials developed will be scheduled for science teachers, including teachers from area secondary schools.

**Integrated Science for Elementary School Teachers: A Course and Practicum Approach to Restructuring Undergraduate Science Preparation for Teachers**

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DUE-9254158
FY 1993 $ 207,597
FY 1994 $ 179,427
FY 1995 $ 124,797
Interdisciplinary

This project is developing and implementing a two-semester course of instruction designed to provide an integrated introduction to science for preservice elementary education (first through eighth grade) majors. Concurrent with an inquiry-centered, laboratory-based content course is the development of a practicum in which the preservice students work with master teachers/mentors to translate science content into actual learning situations for children. This practicum involves teachers and students from the Moscow, Idaho Public Schools, and the Coeur d'Alene Reservation Schools. Additional school districts are being brought into participation as the project matures. At the end of three years, all elementary education majors will be participating in this program. The curriculum is being developed by six research faculty from the departments of chemistry, biology, physics, geology, and biochemistry, in collaboration with science education specialists as well as teachers and administrators from regional schools. The courses present science as a seamless whole through a blending of discovery-based activities and cooperative learning in a technology-rich environment. While this is a content curriculum, it presents science in ways that model the best teaching practices.

**Basics for Technicians: An Integrated Course of Study Encompassing Mathematics, Chemistry, and Physics**

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DUE-9254184
FY 1993 $ 115,000
FY 1995 $ 25,145
Interdisciplinary

Building on experience in programs to upgrade the educational background of personnel working in industry, Dutchess Community College is developing an integrated curriculum which could become a certificate program in basics for industrial technicians. A faculty team is developing a single, unified course integrating elements from what are currently separate courses in introductory mathematics, chemistry, physics, English and reading. Modern manufacturing is being used as the integrating theme. The project will significantly change the undergraduate learning experience through the employment of new curricula, innovative laboratories, new delivery systems, and fresh instructional materials. It is hoped that the project will be a blueprint for the development of an industrial technology certificate granting program which could be replicated by other institutions of higher education, particularly technical colleges.

## Portfolios to Integrate Mathematics, Science, and Computer Science

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DUE-9455559
FY 1995 $294,797
Interdisciplinary

This project is based on the College's successful NSF collaborative computer calculus project in which students create a product in collaborative groups. These products include calculus movies and portfolios, that can be shown to a prospective college admissions committee or employer. A portfolio requires students to make a careful selection, based on evaluation and insight into the process of their education. The program has improved success and retention for women and minorities in calculus. The current project is creating an educational environment that emphasizes the interconnection of all fields of scientific knowledge in order to prepare students more effectively for the scientific environment of the future. This project is improving on the past project by using the portfolio product mode in physics, chemistry and computer science courses, and by adding physics and chemistry and computer science projects throughout the calculus sequence, and to courses in precalculus, discrete mathematics, and differential equations. The results of this project were disseminated to 50 college mathematics and science faculty members through the mathematics department's NSF Undergraduate Faculty Enhancement workshops in the summer of 1995 at BMCC. In addition, the senior faculty of the project publish, read papers and give workshops at MAA, NCTM and other regional, national and international conferences. The impact of this project is the creation of a more diverse and richer scientific environment to strengthen the bases of the mathematics, science, and computer science educational program, computers and collaborative learning.

## Building Environmental Literacy Through Participation in GIS and Multimedia Assisted Field Research

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DUE-9552283
FY 1995 $ 300,000
Interdisciplinary (LLD)

Three related laboratory exercises to support the undergraduate environmental literacy initiative at the University of Georgia are being developed, evaluated, and implemented. This collaborative effort involves the Departments of Geography and Instructional Technology, the Institute of Ecology, and the State Botanical Garden. Students are becoming active participants in long-term ecological studies that require them to test formal hypotheses based on data they collect in the field. They are being assisted by a computerized geographic information system (GIS) as they analyze and interpret results. An interactive multimedia program, which incorporates a performance support system, is guiding them through the field research and data analysis. The following goals are addressed by the project: (1) instruct students from a broad diversity of backgrounds and interests in fundamental scientific concepts including the design and testing of hypotheses; (2) demonstrate the importance of spatial and temporal variation in the study and understanding of natural systems; (3) strengthen geography skills and familiarize students with the

purpose and use of computerized geographic information systems; and (4) create interest in scientific research and science education as career opportunities. The immediate audience is the undergraduate student population of the University, where completion of an environmental literacy course is a requirement for graduation. The project will be disseminated as a model that can be adapted for use at other institutions to increase environmental literacy and expose undergraduates, including future teachers, to new technologies that enhance the study and teaching of science.

## Development of an Integrated, Multidisciplinary Science Literacy Course for Comprehensive Universities

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DUE-9455440
FY 1995 $ 101,620
Interdisciplinary

Recent reports on the state of science education have identified a need for more process-oriented, multidisciplinary science courses; these reports also call for science courses that are integrated within a coherent general education program. This project involves the development of a two semester laboratory-based introductory science course taught collaboratively by faculty members from different science disciplines. Specific objectives of the project include (1) the development of a multidisciplinary introductory science course for large, comprehensive universities; (2) development of methods to link introductory science courses with other courses in the humanities and the social sciences; and (3) investigation of problems associated with collaborative teaching approaches to multidisciplinary science courses.

A multidisciplinary science course, called the Natural World, is being developed by a team of ten faculty from six science disciplines. The course is modular in nature and centers around multidisciplinary topics of current relevance. The Natural World emphasizes the basic foundations of natural science, science as a way of knowing, the uses of science, historical influences on the development of science, and the interrelationships between science and culture. A unique aspect of the Natural World is its integration within a new core curriculum of 38 hours that integrates the various academic disciplines within a set of comprehensive and cohesive interdisciplinary courses. Evaluation of the project includes student and faculty surveys, nationally normed instruments, student portfolios, oral exit interviews, and outside reviewers.

Products being developed as a part of the project are approximately ten modules of multidisciplinary topics that can be used in introductory science courses. Each module includes an instructor's guide, a student guide, suggestions for student and teacher readings, writing assignments, student handouts, and laboratory exercises that involve collaborative and discovery-based learning. A second product being developed is a manual on collaborative teaching for interdisciplinary courses. A third product is information about specific methods for developing connections between science courses and courses in the humanities. Products and project results are being disseminated in written and electronic form and through presentations at national meetings and peer-reviewed papers in scientific journals.

## Student-Active Science: Models of Innovation in College Science Teaching

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DUE-9552886
FY 1995 $ 26,998
Interdisciplinary

Traditional lecture-based courses often lead to lack of student engagement and learning. To improve student learning, faculty from across the country are experimenting with more active, inquiry-based approaches to teaching science. This conference will bring together faculty from various disciplines and diverse institutions to document their success. The conference will be held at Hampshire College in June 1996 and will be attended by about 30 faculty and administrators from 10-15 colleges and universities. The attendees will contribute essays detailing both the specific examples of innovative and effective approaches to classroom and laboratory teaching, and the institutional dynamics necessary to make and keep these innovations. From the interactions at the conference, authors will include ideas and criticisms, comparisons among institutions, and a synthesis of the best of the ideas. These papers and commentary will be published in the conference proceedings.

## The UCLA Science Challenge

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DUE-9455570
FY 1995 $ 149,999
Interdisciplinary

The UCLA Science Challenge began in 1991 as a five-year program with a mission to bring innovative, research-level instruction to undergraduates, particularly lower-division students in order to retain lower-division science majors, recruit new science majors, attract more minority students to science, and improve student attitudes toward science. The goal is to infuse every lower division course in the physical sciences with new material and to create new interdisciplinary courses that reflect the breadth and overlap of the physical and life science disciplines. As the fourth year of the program begins, it is on target to meet its charge. During the first half of the project, participation includes both the largest general education classes in the division, the astronomy and atmospheric science courses, which collectively enroll 8,000 non-science majors each year, and also courses for the physical science majors in chemistry and physics. The major focus now is on the physics course for life science majors. The minor focus, for the enormous general chemistry course that all life science and physical science majors must take, is concentrated on modules that allow students to visualize three-dimensional molecular and crystalline structures. A small presence is being kept in the Earth and space science department, in astronomy, and in atmospheric science in order to maintain the coherence of the renovation of the physical sciences at UCLA and to fulfill a commitment to complete the modules which these departments have begun.

## Fundamentals of Natural Science for Non-Science Students: An Integrated Approach

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DUE-9455413
FY 1995 $ 100,000
Interdisciplinary

A new, integrated course in natural sciences is being developed for non-science majors. This course, Fundamentals of Natural Science (FNS), is the cornerstone for a two-tier, interdisciplinary curriculum in the natural sciences and differs from traditional science offerings in both content and delivery. FNS is being designed to build a foundation for scientific literacy, develop habits of mind consonant with critical thinking, and give students the sense of discovery and accomplishment that comes from "doing science." Because contemporary students have a keen interest in their environment, examples from the natural environment are being selected to illustrate the basic concepts of science under consideration. The examples are being explored in a set of learning exercises designed specifically to promote active inquiry and cooperative learning. These exercises are being developed by faculty and teaching assistants with guidance from the University of South Florida Center for Teaching Enhancement. Textbook and exercise manuals are being developed.

## Modeling Applications in Environmental Management: Preparation of Text and Teaching Guide

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DUE-9455719
FY 1995 $ 100,000
Interdisciplinary

This project is designed to meet a need for well-prepared, modular course materials based on a new, innovative course on mathematical methods in environmental management, one that is adaptable to various educational frameworks. These materials have dual objectives: to teach students about the complex range of everyday environmental issues that are faced by business and governmental organizations, and to give the students first-hand experience in the key role that quantitative modeling plays in dealing with these issues. The present course has a significant field component that includes visits to operating companies and government installations. The purpose of this project is to develop textbook materials and teaching guidance that would enable a wide range of teachers primarily at the college level, but also at the high school level, to incorporate some or all of the same material in offerings at their own institutions.

The subject areas addressed include air pollution, surface water, groundwater, hazardous materials incidents, risk analysis, and public health. Computer analysis is key to many of the activities, ranging from calculation-type programs, often set up in spreadsheets, to information searches on the Internet. In addition, communications skills are emphasized, such as organizing a complex problem description, formulating a solution strategy, and presenting a convincing analysis to others.

During the development process, modules are to be class tested by both the PI and other Bentley teachers, and the material will also be made available to other institutions both in printed form and electronically. The participation of a three-person Advisory Board containing

experienced representatives from a range of institutional types facilitates the targeting of other volunteer test sites. Therefore, in addition to the preparation of the teaching guide, a special teacher training program is also part of the project.

### Integrating the Electronic Desktop into the Natural Science Curriculum

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DUE-9455428
FY 1995 $ 200,000
Interdisciplinary

This project's strategy is to use the power of advanced workstation technology to improve the way science is taught and learned in a multicultural university. Project activities have four faculty persons from biology, chemistry and the earth sciences collaborating to develop three new interdisciplinary courses, write 29 interactive science visualization courseware applications, revise instructional delivery, prepare a variety of instructional materials that can be used at other institutions, integrate Internet resources into the classroom, and create a new class of instructional applications that can be executed remotely over the Internet using the World Wide Web protocol. This project involves, each year, about 200 students who are science majors and 500 general education students. The goals are to increase retention of majors and the scientific literacy of non-majors. Courses are offered in a highly visual, user-friendly, computer-based learning environment that is interactive, powerful, and intuitive. Language barriers are less of a problem in an interactive environment utilizing pictures, animations, sounds, graphs, words and numbers where science can be seen, heard and explored. Engaging students more fully in thinking and problem solving will allow them to learn better. Also, techniques, concepts and demonstrations which are too expensive, dangerous, or do not lend themselves to traditional modes of instruction can be taught despite pedagogical obstacles. Project results will be disseminated through publication, professional presentations, and made available nationally over the Internet.

### Unified Introductory Calculus and Physics

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DUE-9455564
FY 1995 $ 105,292
Interdisciplinary

A team of Occidental faculty in physics and mathematics are constructing a unified freshman program in physics and calculus. The students in the program are those with some deficiencies in pre-college mathematics and science preparation, but who might be motivated to pursue a science or mathematics program as a background for a variety of careers, including medicine, and K-12 teaching. These students are disproportionally female, Latino, and African-American, groups which have long been underrepresented in mathematics and science-based careers. The students enroll in a year-long course consisting of four units in the fall semester and eight units in the spring semester. The pace is relaxed to permit students time to consolidate their mathematics skills and develop physical intuition. In addition, the course includes appropriate use of technology for analysis, simulation and calculation, carefully designed group assignments and

projects, and frequent writing assignments. Further, the students are offered the opportunity to share a corridor in a campus residence hall. Employment of upper-division science students as teaching assistants and residence hall staff helps to integrate college learning with college life. By the end of the program, the students will have a solid understanding of how calculus and physics develop from a few fundamental ideas, and how the disciplines are interrelated. They will develop the mastery of basic math, physics, and communication skills necessary to support these intellectual goals. More importantly, the students will develop attitudes and learning styles that will support further study and success in science and mathematics.

## General Education Course Development for Earth System Science and Global Change

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DUE-9455714
FY 1995 $ 100,001
Interdisciplinary

Undergraduate science education for both students majoring in science and engineering, and those students who are non-science majors must evolve to bring students in contact with the tools needed to efficiently grasp critical and emerging scientific issues. In 1991, the University of Arizona started a two-semester sequence "Introduction to Global Change" to teach non-science majors about the Earth system. The course teaches basic scientific principles in the context of global problems and challenges facing scientists, policymakers and citizens alike. The current project further develops this general-science course sequence in order to more fully integrate information technologies into the courses, and to explicitly design materials that promote collaborative learning and critical thinking skills through several different instructional strategies. PIs are working with an independent, professional evaluator to develop and implement ten modules for the two-course sequence. A module is a course unit focusing on a single topic, and involves laboratory sections, lectures, homework, discussions or other resources. The focus of their efforts is on: (1) developing computer-based laboratory exercises as the centerpieces of the modules; (2) implementing the computer-based tools with the classes; (3) assembling and preparing the additional material needed to complete each module (e.g., visual aids, study questions, background material, references); and (4) documenting each module in a workbook for the classes. The workbook, including documentation of software and data, is being made available to faculty at other colleges and universities interested in developing similar global-change courses. An important aspect of this project is the explicit assessment of the effectiveness of different instructional strategies on students of different gender, ethnicity, and socioeconomic class.

## Taking Ownership: Science as Constructive Inquiry (SCI) - An Interdisciplinary, Urban, Multicultural Curriculum Development Program

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DUE-9455430

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FY 1995 $ 226,589
Interdisciplinary

Brooklyn College is developing, enhancing, and disseminating an intensive, yet supportive, science preparation sequence for urban preservice elementary teachers. For the past five years, college faculty from the four science departments—physics, chemistry, geology, and biology—have collaborated with the science education faculty to design and pilot a constructivist-oriented set of science and science education courses. The purpose of this project is to consolidate the successes of this preliminary program, to build upon pedagogic discoveries, and to strengthen and disseminate a possible major contribution to the Nation's infrastructure in science. Quantitative thinking is being developed as a systemic strand through science courses; this involves the use of lab-based science instruction as a way of teaching mathematics, and using mathematics as a way of allowing active learning to extend beyond the bounds of lab and human scales. The PIs are cooperating with colleagues concurrently working on revision of the mathematics sequence for elementary education majors. Since teaching in the constructivist mode involves a major shift for most faculty, the PIs are working to enhance consistency in teaching throughout the science courses. The science faculty are developing a revised model for setup of laboratory work, to allow for flexibility and spontaneity in student activities. The PIs will prepare a book about their experiences in devising a constructivist curriculum, including discussion of pedagogical, scientific, philosophical, and political issues. In addition to curricular illustrations, the book will demonstrate how faculty with traditional backgrounds can be encouraged, motivated, and taught to develop teaching styles appropriate to inquiry-based learning.

## Multimedia Computer-Assisted Instruction in the Geosciences for Undergraduate Education

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DUE-9455665
FY 1995 $100,000
Interdisciplinary

This two-component project is improving geoscience teaching at the freshman and sophomore levels, particularly for non-science oriented students. A study of concepts and misconceptions brought to the course by entering students using surveys and interviews is being completed. Investigations have discovered some unexpected, "pre-science" misconceptions. Students with the least prior contact with science are likely not to accept or effectively use fundamental assumptions held throughout science like the universality of the most basic laws in time and space. The second component will use the results of this study to guide the creation of computer-assisted teaching modules, initially one on coastal processes and one on mountain building. These modules are interactive multimedia programs which promote participant learning. "Virtual" field trips, animated simulations of processes, and interactive mathematical effects are being constructed. Recognized conceptual problems are being addressed directly, particularly through repetitive interactivity. Branching lines of study are triggered to fill in remedial background for those who need it. Authorware Professional is the intended programming tool for

the highest level multimedia interactions. The project will be evaluated by repeating the survey approach. The teaching modules will form the basis for publishable CD multimedia programs.

## Pacific Northwest Environmental Studies Program: A Collaborative Interdisciplinary Curriculum Development Project

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DUE-9455726
FY 1995 $ 121,511
Interdisciplinary

The Pacific Northwest Environmental Studies Program (PNESP) is an undergraduate curricular collaboration among four Pacific Northwest higher education institutions: Portland State University, Oregon Institute of Technology, Clatsop Community College, and Lower Columbia College. The program addresses the need to prepare students to enter one of the region's principal growth industries, environmental technology. This academic partnership allows the participating schools to pool their resources, field work opportunities and expertise to deliver a fully-transferable two-year curriculum in more depth and with broader scope than is possible without the collaboration. The curriculum development process includes both academic year meetings and summer faculty development programs that engage faculty from all participating campuses and involve professionals from the environmental industry. Thus, the program fosters the concept of an environmental teaching, learning, and service community among the faculty, students and industry professionals. The PNESP opens an avenue of seamless transition for students from precollege programs to upper division coursework. The PNESP core courses also serve to prepare students to enter teacher education programs that are aligned with Oregon's K-12 Natural Resource Systems Certificate of Advanced Mastery. The PNESP curriculum of introductory courses and field experiences will become the core element in environmental baccalaureate, associate and certificate degree programs encompassing science, policy, technology, and engineering on the participating campuses.