Project Description

Improving environmental science and engineering education is of national importance. Environmental issues provide excellent vehicles for gaining scientific knowledge and acquiring skills in problem solving, consensus building, information management, communication and critical and creative thinking (NSF 2000). Humboldt State University (HSU) has one of the oldest and largest ABET (Accreditation Board for Engineering and Technology) accredited programs in environmental engineering in the nation and a new program in environmental science. The ability to work on interdisciplinary teams is one of the new ABET 2000 criteria (ABET 2000). The HSU College of Natural Resources (CNRS) recognizes the importance of the Environmental Science (ES) and Environmental Resources Engineering (ERE) majors working together in interdisciplinary classes and encourages faculty innovation in the classroom. This support is demonstrated in the financing of a new teaching facility, the ERE Design Studio.

The project PIs --Dr. Cashman and Dr. Eschenbach -- have been team-teaching introductory engineering courses for two years. They have implemented curriculum incorporating collaborative learning and teamwork in an introductory engineering design course (Eschenbach 1997; Eschenbach 1998). The course was so successful that HSU's new environmental science program began requiring the course for their majors. As a result of the larger and more diverse classes for this course, the curriculum needs adaptation. The ERE faculty want to incorporate a collaborative approach to the environmental science and engineering curricula that examines the relationship between environmental science and engineering and our management of natural resources. In addition, these courses need to be designed so that they can be easily taught by multiple ERE faculty. We propose to develop two new laboratory courses, *ERE 115 Introduction to Environmental Resources Engineering and Science* and *ERE 215 Introduction to*

Design, to build on the existing strengths in science and engineering within the College of Natural Resources at Humboldt State University.

HSU is 250 miles north of San Francisco and 90 miles south of the Oregon border, nestled between the Pacific Ocean and rugged, coastal mountain ranges. It is the region's center for research and education in natural resources. The region's extraordinary network of rivers, lagoons, wetlands and coastal bays have made it central to several national policy debates on the critical natural resource issues of our time.

HSU has a strong tradition of undergraduate education and has consistently been a leader among universities in producing future scientists and engineers. When campus size is taken into account, Humboldt ranked first in Ph.D. production among 529 campuses classified as "master's colleges and universities" (NSF 1996). HSU has 7000 students, the ERE department services approximately 200 students and the ES department has in excess of 300 students in the major and continues to increase every year.

Hands-on undergraduate education and research are strong components of the ERE and ES programs at HSU. Faculty take advantage of off-campus research sites and field laboratories, including the Schatz Energy Research Center, the Fred Galbreath Wildlands Center and 700 acres of University forests. Within walking distance of HSU are 154 acres of marshes, lakes, and oxidation and fish-rearing ponds including the award-winning Arcata Marsh and Wildlife Sanctuary, one of the nation's first constructed wetlands to be used as a municipal wastewater treatment plant. The student-managed Campus Center for Appropriate Technology (CCAT 2001) has been a successful demonstration site for appropriate technologies for over 20 years.

CNRS attracts a diverse student body. Forty-four percent of CNRS students were female in fall semester 2000. Nationally, about 18 percent of engineering students are women, while 27

percent of ERE students are women. Student ethnicity is primarily Caucasian (66%), but students' age has a large range with a median student age of 26 years.

Both of the courses targeted within this project will be required introductory courses for ERE majors. One of the courses (*ERE 115: Introduction to Environmental Engineering and Science*) will be required for ES majors and many ES majors may choose to take the second course (*ERE 215: Introduction to Design*). The projected enrollment, based on the number of current majors, and the enrollment of the previous introductory courses over the past five years, is 50-100 students per semester for ERE 115 and 24-50 students per semester for ERE 215. Over the three-year project period, we expect to affect between 425-850 majors in ERE and ES.

Goals and Objectives: The project goal is to redesign two introductory courses in the ES and ERE curriculum: *ERE 115: Introduction to Environmental Resources Engineering and Science* and *ERE 215: Introduction to Design* so they will provide students a more integrated interdisciplinary approach to solving environmental problems. Students will obtain the knowledge, skills and attitudes that will make them successful in their chosen major. In particular, the courses will provide students: 1) an interdisciplinary presentation of environmental and human systems via hands-on team projects, field and lab experiences, 2) a clear presentation of course requirements and career paths available to environmental scientists and environmental resources engineers, 3) an opportunity to develop computational skills, technical communication skills and teamwork skills via environmentally relevant projects and field and lab experiments, and 4) an increased confidence in one's ability to complete one's chosen major based on multiple successful hands-on projects, field and lab experiences.

This proposal requests three years of funding to support the development of curricular materials and the acquisition of laboratory equipment to meet the learning goals and objectives

outlined above. The Rensselaer Polytechnic Institute studio teaching approach (Wilson 1994; RPI 1999) and Just in Time Teaching (JiTT) (Novak et al. 1999) will be used in the development and modification of curriculum for the two courses ERE 115 and ERE 215. Student learning will be facilitated by mini-lectures and small-group, collaborative-learning case studies based on primary literature, laboratory experiments and fieldwork. These case studies will focus on exciting and controversial issues in the environment. For example, water issues will be explored by adapting the NSF sponsored PROMISE project module *Water: Resources, Politics and Society* so that it addresses local water issues (Mayberry et al. 1999; PROMISE 2001c). We will use WebCT (WebCT 2001) to integrate web technology throughout the curriculum as suggested by the JiTT approach. During the last year of the project, another ERE faculty member, Dr. Margaret Lang will test the usability of the curricular materials by teaching one or both courses.

Detailed Project Plan: This section outlines Studio Teaching, Just In Time Teaching, the PROMISE project, and the WebCT software. We also present descriptions of how these methods will be modified to revitalize the curriculum for ERE 115 and ERE 215.

Studio Teaching: In 1988, RPI introduced the integration of technology into a cooperative learning environment (Wilson 1994). The Studio Teaching approach integrates lecture, laboratory, and recitation by exploiting computer-based materials as a tool to accelerate, integrate, and leverage interaction. Studio courses engage students in various problem solving and active learning sessions and help students to construct their own understandings of course concepts. The integration of lab work directly into the course makes the lab work more relevant and ensures that the lab and course materials are in step. Evaluations conducted by Wilson (1994) demonstrate that students learn the material better and faster when compared to the traditional science courses. Additionally, students' attitudes towards science improved and both

students and faculty enjoyed the material (Wilson 1994; Williams et al. 1996). RPI has recently received the Hesburgh Award for Faculty Development to Enhance Undergraduate Teaching, the Boeing Outstanding Educator Award and the Pew Leadership Award for the Renewal of Undergraduate Education (RPI 1999).

Just-in-Time Teaching A Web-based strategy comprised of active learning classroom activities and World Wide Web resources that enhance the classroom component has been pioneered as a collaborative effort of physics faculty at the United States Air Force Academy, Indiana University-Purdue University Indianapolis (IUPUI), and Davidson College. To date, the Just-in-Time Teaching (JiTT) strategy has been adopted and adapted by faculty at more than 50 institutions across the country (Novak et al. 1999).

At IUPUI, students complete World Wide Web-based Warm-Up assignments, which are due by electronic transmission a short time before class begins. Instructors in the interactive lecture then adjust and organize lessons based on those student responses. The students come to class prepared and already engaged with the material, and the faculty member knows where the students are in the learning process and can better judge where classroom time should be spent.

There is documented increased attendance and decreased attrition with the implementation of JiTT (Novak and Patterson 1997; Rozycki 1999). Of those surveyed after two semesters of JiTT courses, 92 percent preferred the approach to a standard course. This preference is likely due to the fact that JiTT has at its core increased amounts and quality of student-to-student interaction, student-to-faculty interaction, and time on task. These three factors have been identified as important to student success (Astin 1993). Dr. Cashman has attended a NSF sponsored Project Kaleidoscope workshop on JiTT and is prepared to modify curricula using this approach.

PROMISE Project: The Project for Multicultural and Interdisciplinary Study and Education (PROMISE) is an experimental knowledge project conducted at the University of Nevada, Las Vegas. Funded by NSF's Program for Women and Girls, PROMISE is a three-year collaborative project among Geoscience, Sociology, and Women's Studies. PROMISE's goal is to build upon feminist critiques of science by integrating studies of science and feminism (PROMISE 2001a). The PROMISE project developed and tested new evaluation instruments to test the outcomes of this integration. These tools are available on the investigators' web site (PROMISE 2001b). In the PROMISE project, the investigators evaluated the effects of the courses at the university level in four distinct areas: 1) level of confidence, 2) level of interest, 3) attitude toward classroom participation, and 4) orientation toward praxis (putting theory in to practice).

Using their assessment instruments, the investigators in the PROMISE program have concluded that students in the feminist science courses made tremendous gains in "participatory orientation" during the span of a semester, while holding steady on their level of interest and confidence in geoscience topics. In sharp contrast, students in the traditional introductory earth science courses (both the class as a whole and the subset of women students) experienced significant declines in both confidence and interest while showing no significant increase in participatory orientation (Promise 2001b). Both PIs attended an NSF sponsored workshop that presented the PROMISE materials and are prepared to adapt them.

WebCT: Educators at more than 2,200 colleges and universities in 79 countries use WebCT, which is a web based course management system (WebCT 2001). The software is flexible and provides faculty with tools to enhance student-to-student and student-to-faculty interaction. HSU has a site license for the software and both PIs have attended WebCT training sessions.

Modification of Methods and Materials: The Studio Teaching and JiTT methods will be used to redesign the curriculum of both ERE 115 and ERE 215. Both courses will require students to work in small groups and will be taught in the new ERE Design Studio, which will be completed by the fall of 2001. The ERE Design Studio was developed with the Studio Teaching approach to engineering education in mind. Here, we will systematically incorporate technology in a cooperative learning environment. We seek to reduce the emphasis on the lecture, to improve the relationship between the course and the laboratory, to scale up the amount of doing while scaling back the amount of watching, to continue and expand the team and cooperative learning experiences and to integrate rather than overlay technology into the courses. The room is set up so student teams can easily organize their workspace and have access to white boards and to computers. The ERE Design Studio will facilitate the use of cooperative learning (Johnson, Johnson and Smith 1991), which is used both in Studio Teaching and JiTT.

The Studio Teaching approach will require the development of mini-lectures that occur between small group activities. In addition, our current set of experiments and field activities will need to be redesigned so that they are integrated in the context of the Studio Teaching and JiTT approaches. We will create lab experiences that require students to design experiments completed in nearby field locations or laboratories and then the analysis and team write up is completed in the Design Studio.

The courses will use an integrated approach in both content and pedagogy. While learning how to use science and engineering to manage our natural resources, students will also develop their teamwork skills, technical communication skills and computational skills. We will develop course modules that emphasize these skills while using an active approach to learning about different environmental resource issues or the design process. Modules for ERE 115 will address

our water, air, earth and energy resources. Modules for ERE 215 will address topics such as the engineering design process, teamwork, learning styles, technical communication and professional ethics.

We will develop WebCT sites for each course. Each WebCT site will house and deliver the Warm-Up exercises for each course module using the JiTT approach. In addition, WebCT will be used to provide an online forum for student-to-student communication and student-to-faculty communication. Each student team will use private WebCT "team only space" to interact with each other, store project documentation and communicate with the instructor via weekly on-line updates. In addition, a course-wide "public space" will be available for students to communicate with all students, as well as "publish" their final reports for all students to view.

Development of the Water Resources module for ERE 115 will require the modification and adaptation of PROMISE module: *Water: Resources, Politics, and Society*. In this module, students will "learn through self-reflection, classroom presentations, laboratory exercises, library research, and fieldwork how our perceptions about water quality and availability are socially constructed, how historical values and attitudes have shaped our current situation, and how our present choices will determine future access to clean water supplies" (PROMISE 2001c). The adaptation of this module will require that the PIs identify local water resources issues for students to research. In addition, appropriate supportive materials will be developed for WebCT.

The PROMISE approach will be used when developing other ERE 115 and ERE 215 modules. The integration of social, political, economic, ethical, and scientific issues used in the PROMISE approach is well aligned with the mission of the ERE program at HSU: "to provide a professionally recognized, high quality education that prepares engineers to identify, evaluate and solve complex problems involving the management of environmental resources. This

preparation emphasizes understanding environmental resources problems in their technical, ecological, socio-political, economic, historical and ethical context, and the design and implementation of appropriate solutions at the regional, national and international levels."

Experience and Capability of the Principal Investigators: Dr. Cashman is an Assistant Professor of ERE. She received her Ph.D. in Civil and Environmental Engineering from University of Wisconsin-Madison in 1997. Since January 2000, Dr. Cashman has taught courses at HSU in engineering design, water quality, fluid mechanics, applied hydraulics and river hydraulics. Prior to her appointment at HSU, Dr. Cashman taught at James Madison University (JMU) in the 2-year-old Integrated Science and Technology program (ISAT). The ISAT program at JMU is an innovative effort to create a new kind of education for students interested in both the details of science and technology and their impact on society. Dr. Cashman was directly involved in much of the curriculum development for the new Environmental Science section of ISAT.Dr. Cashman has experience teaching to both ES students (at HSU and JMU) and ERE students (at HSU).

Dr. Cashman is a member of Faculty for the 21st (F21) century. F21 is a faculty network supported by Project Kaleidoscope (PKAL), an informal national alliance of individuals, institutions, and organizations committed to strengthening undergraduate science, mathematics, engineering, and technology education. Dr. Cashman has participated in several PKAL workshops sponsored by NSF on the Studio Teaching and JiTT approaches. She has also presented at a PKAL sponsored workshop on the integrated approach in JMU's ISAT program.

Dr. Eschenbach is an Associate Professor of ERE, where she teaches introduction to design, probabilistic analysis of environmental systems, computational methods, environmental impact assessment, hydrology and water resources systems management. She received her Ph.D. in

Environmental Systems Engineering from Cornell University in 1994. While at Cornell, she was awarded the Dean's Prize in Teaching Excellence for her work organizing the Teaching Assistant Development Program for the College of Engineering. In addition, she was voted best teaching assistant in the School of Civil and Environmental Engineering.

Eschenbach is active in the Educational Research and Methods Division (ERM) of the American Society for Engineering Education. She has represented ERM as a workshop facilitator at multiple conferences and universities. In 1994 she was awarded the ERM Apprentice Faculty Grant. With Karl Smith and Jim Jones she received the Helen Plants Award for most innovative session at the 1997 Frontiers in Education Conference. In the session "Conversations on Creating a Different Classroom Climate " she discussed and modeled methods for using cooperative learning in large classrooms. Dr. Eschenbach has been nominated to be a member of Faculty for the 21st Century, a faculty network supported by PKAL.

Cashman and Eschenbach: Dr. Cashman and Dr. Eschenbach have been team teaching introductory engineering courses for two years. Drs. Cashman and Eschenbach have led a workshop on teaching with teams as part of the faculty development program at HSU and they will be co-facilitating a workshop on group work at the 2001 Frontiers in Education conference. Both faculty members attended an NSF sponsored Women in Science Curriculum Reform Institute in June of 2000, and will be attending the PKAL Summer Institute this July.

Outcomes and Dissemination of Results: Upon project completion, we expect ERE and ES students to have an increased confidence in their ability to complete their chosen majors. We will have developed WebCT course modules that provide an integrated introduction to environmental engineering and science and introduction to design. These modules will be developed so that other ERE faculty can easily use them when teaching ERE 115 or ERE 215.

They will be available and should be useful to the following programs at other universities: environmental engineering, environmental science, general education, and freshman design. In addition, high school instructors could adapt the modules.

We will disseminate our work via course web pages, presentations at national meetings, on- and off-campus faculty development workshops and publications. This project addresses NSF's themes of diversity and integration of technology in the curriculum. The two PIs are women in a field where women are underrepresented. In addition, the PROMISE curriculum approach as been shown to be more inclusive of underrepresented groups in SMET areas. Both the JiTT and Studio Teaching approaches require the integration of technology in the classroom.

Evaluation Plan: The project will have four separate forms of evaluation: formative, process, outcome, and summative that will be conducted by internal and external evaluators. The formative and process evaluations will focus on course improvement. The summative and outcome evaluations will provide information about what happens to participants at the conclusion of the courses and the project. Outcome data will provide useful information for formative purposes, and process data will aid in understanding the conditions that led to different outcomes and therefore will provide summative guidance.

The internal evaluations will be performed by the PIs, while Dr. Jeffrey White and Ms. Doreen Espinoza will perform external evaluations. Dr. Eschenbach has attended numerous training sessions in outcomes assessment related to ABET 2000 criteria. Dr. Cashman has attended national and regional workshops related to learning outcomes assessment. Dr. White is an assistant professor in the Department of Biological Sciences at Humboldt State University. Dr. White is the elementary science education specialist and is currently the co-director and the internal program evaluation coordinator for the Redwood Science Project, a summer teaching

institute for K-6th grade teachers. Ms. Espinoza is a Ph.D. candidate at Michigan State University in the College of Education and is completing her dissertation in Arcata, which focuses on policy-practice analysis. She has completed graduate courses in education policy and practice, analysis and evaluation of education programs, qualitative research methods in education, and numerous quantitative statistics courses.

Formative Evaluation: The formative evaluation will occur during the design and early phases of the project and will be conducted primarily by the PIs with contributions from the external evaluators. The purposes of this evaluation are to identify project components that effectively meet goals, devise effective assessment tools, determine how well the project procedures and timelines are being met, and identify information for project improvement. The following questions will be addressed: 1) What student outcomes can be measured to determine if students have an improved preparation for the majors of ES and ERE? 2) What student outcomes can be measured to determine if students' confidence in their ability to be successful in one's major is increased? 3) How will PIs determine if the JiTT, Studio Teaching approach, and PROMISE materials are improving student outcomes?

Process Evaluation: Internal and external process evaluation will be conducted to provide information on how the project is progressing. The focus will be on course activities, teacher practices, and student actions. Questions addressed during this analysis may include: 1) How are instructors' decisions and practices impacted by the project? 2) What characteristics of the project are evident in the teaching of the courses and the course documents and why? 3) What dimension of change (e.g., superficial, real, none) has occurred in the courses as a result of the project? 4) How easily can another ERE faculty member (Dr. Margaret Lang) adopt the materials?

The external evaluators will conduct non-participant observations of course instructors and analysis of documents such as course syllabi, and course and lab assignments. The course and laboratory observations will take place once per semester throughout the three years of the project. The field notes and videotape data will be coded according to the stated project goals and objectives. Documents will also be analyzed according to stated goals and objectives.

The internal evaluators will administer assessment tests and on-going laboratory/course evaluations that are based on PROMISE materials (PROMISE 2001b), those found at the Online Evaluation Resource Library (SRI 2001) and those in the Field-tested Learning Assessment Guide (NISE 2001). Some of these assessments will be completed online using either WebCT or Student Assessment of Learning Gains software (Seymour 1997). Instructors will use this anonymous information to help them understand the perceptions and experiences of the students. Particular attention will be addressed towards course activities or learning techniques that are new to the instructors and students.

Outcome Evaluation: Internal and external outcome evaluations will be conducted to determine if the project actualized the intended results and to determine what happened to the students after their participation in the courses. The questions to be addressed during this evaluation process include: 1) Do students have an improved preparation for the majors of ES and ERE? 2) Has students' confidence in their ability to be successful in one's major increased? 3) Are JiTT, and Studio Teaching implemented adequately and are PROMISE materials modified adequately? Pre- and post-attitudinal questionnaires will be administered to students at the beginning and end of each semester of the project. Semester end course and instructor anonymous evaluations will be administered by the PIs. Instructors will not see the results of this evaluation until after grades have been submitted. External evaluation will include focused

group interviews to assess how the courses affected the students' knowledge, skills and attitudes. One interview will be conducted within 3-6 months after the completion of the course. A final interview will be conducted in the students' senior year. These interviews will occur beyond the 3-year funding cycle of the project if necessary.

Summative Evaluation: Summative evaluation will occur after project completion. This evaluation provides information about the effectiveness of the project and to what degree the project met the stated goals and objectives. The external evaluators will analyze results from the process and outcome evaluations and provide a written report to the PIs. The report will include a summary of the data analysis, and conclusions and recommendations about the project.

Project Time Line: The proposal requests three years of funding beginning Spring 2002. Most of the course development will occur during the first two years. The courses will be continually improved during the rest of the project based on student outcome data. *ERE 115: Introduction to Environmental Resources Engineering and Science* will be developed and implemented first. *ERE 215: Introduction to Design* will be developed and implemented second. Each semester Cashman or Eschenbach will use the ERE-CNRS-HSU sponsored release time to develop ERE 115 and ERE 215. Cashman and Eschenbach will work closely and teach ERE 115 and ERE 215 during the first two years. During the last year, Dr. Margaret Lang will teach ERE 115 and ERE 215 with Cashman and Eschenbach. Internal and external evaluation will occur throughout the project. Table 1 provides an overview of the project schedule.

Table 1: Project Gantt Chart:

Task	2002			2003			2004		
	Spring	Summer	Fall	Spring	Summer	Fall	Spring	Summer	Fall
Project Planning									
Develop ERE 115									
Develop ERE 215									
Implement ERE 115									
Implement ERE 215									
Continue to develop ERE 115 based on project evaluation									
Continue to develop ERE 215 based on project evaluation									
Dr. Margaret Lang tests ERE 115 curriculum									
Dr. Margaret Lang tests ERE 215 curriculum									
Project Evaluation									
Final Report									

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