PROJECT SUMMARY

Field courses make critical connections between principles described in the classroom and scientific problems encountered in practice, and these connections are essential to both sparking intellectual curiosity and training essential competencies of students. However, there are many barriers to successful field courses because they are expensive to conduct, logistically demanding, and require a diversity of faculty expertise. As a result, only a few intensive field courses are available in the hydrologic sciences, even though students in geology, environmental sciences, civil engineering, aquatic ecology, forestry, K-12 teaching and many other disciplines could benefit from this training.

The objective of this project is to modify several existing courses to develop a six-week-long intensive field course in hydrologic sciences. The new course will be developed and taught by faculty from a consortium of universities. An initial organizing group of faculty, drawn from the more than 30 who responded enthusiastically to our initial inquiries and others, will come together to address logistical and technical issues. The project will consist of developing teaching methods for modules in hydrologic science field methods and field settings that will then be offered as a prototype 6-credit course at Clemson University during the summer of 2006. This effort will be evaluated through a variety of techniques, refined, and taught a second time during the summer of 2007. The resulting materials will be disseminated through conference presentations and through the Consortium of Universities for the Advancement of Hydrologic Sciences, Inc.(CUAHSI), an organization currently representing more than 100 universities with interests in the hydrologic sciences. We envision that this project will ultimately lead to a network of regional hydrologic science field courses in the U.S. coordinated by CUAHSI. Northern Illinois University and Illinois State University are involved with development at the outset to ensure that a second region, in a very different setting, is considered while modules are developed.

The primary **intellectual merit** of this project is that it will develop new instructional materials for a modern and sustainable field course in hydrological sciences. These materials will be available to others who want to offer similar courses, and they will serve as important reference materials for practioners in hydrologic sciences. Moreover, the project will provide solutions to the myriad logistical problems associated with offering a field course taught by a group of faculty from different institutions.

Hydrologic sciences provide essential insights into a **broad** range of economic, environmental, ecological, and political issues facing our society today. By ensuring the availability of excellent field training to a wide range of students, this project will have a **broad impact** by inspiring and strengthening the scientific backgrounds of the next generation of Earth scientists.

RESULTS FROM PRIOR NSF SUPPORT

None of the investigators have received an NSF educational grant in the last 5 years.

PROJECT DESCRIPTION

Field camp is a keystone course for the geological sciences because it completes a connection between the principles described in the classroom and the scientific problems encountered in practice. Nearly every undergraduate program in geology requires a five- to six-week-long field camp experience to ensure that their students make this connection. Hydrologic science, which incorporates aspects of geology, hydrology, geomorphology, biogeochemistry, limnology, and ecology for the study of water, currently offers one of the strongest career paths for earth scientists. Hydrologic science demands making a unique set of connections between principles and practice. A few degree-granting programs have responded to this demand by offering rigorous learning experiences through field camps that specialize in hydrogeology (Van der Hoven and Lenczewski, 2002; McKay and Kammer, 1999; Benson et al., 1996). These camps have been highly successful catalysts for professional careers in hydrogeology because they provide a learning experience that cannot be obtained in any other way. This proposal expands this concept to embrace the broader hydrologic science discipline.

Only a handful of hydrogeology field camps are available so few undergraduate students have the opportunity to include this experience in their education thus creating a barrier to learning. Field camps require substantial investments in equipment, facilities and faculty time, so budget constraints have forced some universities to close their hydrogeology field camps, while others have been reluctant to open new camps. Moreover, field camps demand both a broad range of expertise and significant time commitment by participating faculty, and these requirements have further limited the number of hydrogeology field camps available to students.

We propose to develop a hydrologic science field course taught by faculty from a regional consortium of universities, who pool their expertise and time to meet the objectives of the camp. The camp will be hosted by one university, with faculty contributors and trips to field sites across the region. The camp will be organized into structured, week-long modules, which can be taken individually or as sequence of five or six modules to fulfill field camp requirements. This will maximize accessibility of the course to a broad range of students. Moreover, the modular structure will facilitate moving the camp among different host universities, rotating the faculty involved in teaching, and developing collaborative field camps in other regions.

This collaborative approach to teaching a field course is innovative, but by no means is it without precedent. A consortium of universities in North Carolina and Virginia currently offer a field camp in geology (http://people.uncw.edu/smithms/), and Northern Illinois University and Illinois State University (NIU/ISU) pull together to offer an environmental field camp (http://jove.geol.niu.edu/courses/environ_fieldcamp/env_fieldcamp.html). Nevertheless, developing and sustaining a group-taught field course will require considerable coordination among participating universities, and for this reason we propose to conduct this project as a collaboration between Clemson University and the Consortium of Universities for Advancement of Hydrologic Sciences Inc. (CUAHSI). CUAHSI currently represents more than 100 universities with programs in the hydrologic sciences, and we will draw on this group to organize the proposed project.

OBJECTIVE AND GOALS

The objective of this project is to reorganize and refine existing teaching materials to increase the accessibility, quality, and sustainability of a comprehensive field course in the hydrologic sciences. This proposal is a combination of a Type 1 (adapt and implement high-quality instructional material) and a Type 2 (overcoming barriers) projects. This will be achieved by accomplishing the following goals:

1. Organization and logistics: Develop a multi-institutional organizational structure among faculty and staff within the consortium that will be used to implement the program.
2. Teaching materials: Prepare lesson plans, notes, computer programs, handouts and other materials for teaching modules of selected field topics in the hydrologic sciences.
3. Pilot implementation: Teach the prototype field course at Clemson University.
4. Review and assessment: Conduct peer-review of course materials, and assess pedagogical materials by external experts. Refine course based on review.
5. Dissemination: Present publications and coordinate transfer of teaching and organizational materials to develop other regional field camp consortia.

TARGET STUDENTS

The field course will primarily target undergraduates, but we expect that it will reach students at a broad range of levels. Nearly every undergraduate program in geology requires a four to six-week-long field camp experience and these students will be our primary target. In addition, undergraduate students in environmental science, civil engineering, forestry, agricultural engineering, aquatic ecology and related disciplines will also benefit from this course. Undergraduates who are pursuing K-12 teaching certificates with emphasis in Earth science will find this course gives them a wealth of hands-on learning experiences that they can take back to their students. Making the field camp attractive to K-12 teachers will motivate them to include modern hydrologic science in their classes, and this will inspire the next generation of hydrogeologists (Repine et al., 2000). The modular format of the course should allow in-service teachers to fulfill their continuing education requirements, further expanding the impact of the course. Graduate students interested in pursuing a thesis involving field hydrology will also be attracted to this program, and we intend to structure some of the modules to meet the requirements for continuing education for professional geologists.

DETAILED PROJECT PLAN

The project will develop a hydrologic science field course taught by faculty from a group of universities in the southeastern U.S. The project will be conducted as a collaborative effort between Clemson University and CUAHSI. Development of pedagogical materials will be coordinated through faculty at Clemson University and Northern Illinois University, whereas organization of the consortium and coordination of review and assessment will be conducted by CUAHSI.

The proposed course will be based on instructional materials currently used at hydrologic field camps taught at Clemson University and NIU/ISU, and it will draw on instructional materials contributed by faculty participants from other universities (Type 1).

The field camp course will be organized into several structured modules based on different topics. One set of modules will focus on mastering different *field methods*, whereas

another set will focus on understanding *hydrogeologic settings*. Each module will be full-time, all-day instruction lasting approximately one week, and the course will consist of multiple, consecutive modules. The modules will stand-alone so they can be taken individually for 1 credit each, or as a sequence for 5 or 6 credits. This will broaden accessibility to students, who may be unable to attend the entire duration. Moreover, the module format will also facilitate development of additional regional camps and collaboration within a network of field camps at different universities. For example, some students may want to learn field methods at camp near their home for logistical convenience, but then travel to another camp to learn about hydrogeologic settings in that area.

The project will be initiated by holding a Planning Meeting for interested faculty participants. The objectives of this meeting are to 1.) identify critical logistic issues that must be solved to implement and sustain the course, and 2.) review important approaches and materials to be included in the modules; and 3.) identify teams of participants interested in developing and teaching modules. Some of the people have already been identified (Senior Personnel) or have expressed interest (Appendix 1) in developing the camp.

Instructional materials will be developed and tested by faculty participants prior to implementation. The modules will be taught at a prototype field course hosted by Clemson University at the end of the first year of the project. Preliminary review and assessment will be conducted at the end of the first year, and recommendations will be included by modifying course material during the second year. A formal peer-review and a detailed assessment of the course will be conducted after the second year. The course will be modified and improved based on these evaluations and the product of these refinements will be disseminated.

The project will include five major tasks outlined below.

1.) Develop organizational structure and solve logistical issues

A consortium of universities interested in participating in the field camp effort will be developed and various logistical issues will be identified and solved. For example, we anticipate there will be issues related to faculty compensation, recognition, travel and housing. Tuition costs and credit transfer, along with travel and housing costs, insurance coverage and other logistics are issues that will affect students.

A Planning Workshop for interested faculty will be held at the beginning of the project, and one of the objectives of this meeting will be to identify organizational and logistical issues that are critical to success. Faculty from more than 30 CUAHSI-member universities have expressed interest in recommending the proposed field camp to their students and in participating in developing modules for the camp (details in Appendix I).

A field camp website will be developed at the beginning of the project. The website will be used to provide logistic information for students and participating faculty, and it will be used as a source of instructional materials for students and others interested in field hydrologic science.

2) Develop educational modules

This task involves developing the educational modules in field hydrologic science that will form the basis for the course. The modules will be partly based on materials and practices that have been developed at field camps at Clemson University and NIU/ISU (Type 1). This material will be supplemented with input from faculty at universities in the consortium.

Another objective of the Planning Workshop will be held to bring together potential participants and other interested personnel (e.g. recent graduates of hydrogeology field camps) to discuss the development of instructional modules. Important ideas identified during the Planning Workshop will be refined by teams of instructors working on each module.

Activities involved with developing the Methods modules include compiling detailed sets of notes, background papers, sample problems, and field exercises. Data worksheets, computer spreadsheets, and data analysis software will also be developed or identified for use. Notes describing how to conduct the field exercises and analyze the resulting data will be prepared as handouts for the students. In addition, notes describing the field conditions, infrastructure, and equipment required to conduct the exercise will be prepared for participating faculty. This will facilitate the involvement of new faculty, and it will shorten the logistics of preparing for each exercise. Additional notes will be prepared describing locations and background information for trips showing examples of hydrogeologic settings—a format similar to some field trip guidebooks. Instructional materials will be distributed in class, and they will be accessible online on a website developed for the course. Course content will also be formulated with professional accreditation requirements (e.g, Professional Geologist, Professional Hydrologist) in mind.

This project will produce instructional materials for six modules in Hydrologic Science Methods and three modules in Hydrogeologic Settings. Some of the modules may be offered every other year, depending on time constraints and student demand. The modules that we intend to develop include:

Hydrologic Science Methods

- Vadose zone characterization: Describing soils; measuring unsaturated properties; evapotranspiration measurements; characterizing shallow hill slopes.
- Aquifer characterization: Pumping and slug tests; water, soil, and rock sampling; televiewer; flowmeter; packers; drilling and well completion.
- Surface water characterization: Stream gauging; groundwater-surface water interaction; sediment and water sampling; geomorphology.
- Shallow geophysics: Ground penetrating radar; electromagnetics; resistivity; seismics; borehole methods.
- Subsurface remediation: Vapor extraction; air sparging; dual phase and NAPL recovery; pump and treat; reactive media; sampling contaminated soil and water.
- Biogeochemistry: detection of organic compounds in water; trace gas sampling; inorganic chemical analysis of water; pathogenic microorganisms detection in water.

Hydrogeologic Settings

- Paleozoic karst Trip includes karst hydrology and geomorphology in Mammoth Cave area, and selected locations in Tennessee and Kentucky. Dye tracing and environmental investigations will also be included.
- Fractured Crystalline Rock Trip includes mapping saprolite, and projects involving characterizing contaminated sites, and watershed hydrology in the southeastern Piedmont.

- Atlantic Coastal Plain Trip includes mapping exposures of important sand aquifers and confining units, interpreting processes controlling heterogeneities, visiting various depositional environments along the coast in South Carolina and Georgia.

3.) Module Testing

Successful implementation will require that all teaching activities achieve the desired results in the allotted time. This can be difficult to achieve under field conditions, where travel times, equipment set-up, data acquisition, and evaluation can be difficult to anticipate. To ensure successful implementation, we will test the modules prior to implementation. Testing will be conducted by participating faculty working with student assistants, who will conduct the exercises using the same procedures planned for implementation. Testing will be conducted for both the initial modules, and for the modules that have been modified based on assessment and review.

4) Implementation the pilot field camp at Clemson University

A pilot trial of the modular field course will be implemented at Clemson University during summer 2006. The initial course will consist of approximately six modules offered during the first summer session in May and June. A student assistant who participated in module testing will assist with implementation.

5) Assessment, Refinement, Dissemination

Peer review, internal review, student feedback will be used during the project to identify how to improve the field camp (more details are in the Evaluation Plan). Insights from the formative evaluations will be used to improve field camp during the following year.

Descriptions of organizational hurdles and instructional methods developed during the project will be published in peer-reviewed journals. Instructional materials and information about the camp will be posted on a course website that will serve as a resource to both current students, and to the field hydrogeology community in general. More details are in the Dissemination Plan.

Duration and Timing

The proposed project will last for 3 years. A Planning Meeting will be held within the first few months of the project, and the first prototype field course will be conducted at the end of the first year. We expect that important changes will be made based on feedback from students and reflections by faculty after the first year, and significant refinements will result from evaluations, including peer-review, after the second year.

We propose to start the project during the summer of 2005 and offer the first field camp during summer of 2006. A second field camp would be offered in 2007, with the final evaluation and final reports for the project in the succeeding months. The project would support efforts through spring of 2008.

Growth and Synergy

We envision that this project will be a prototype effort that will grow into a coordinated network of other regional field courses across the U.S. CUAHSI is developing a network of Hydrologic Observatories, with the first of these slated to begin field operation in late 2006. The proposed project may develop modules at the Hydrologic Observatories (depending on the

locations of the sites selected as Observatories), and we expect that future regional field courses will also utilize the observatories. Furthermore, a pilot Hydrologic Measurement Services program of CUAHSI is also under review at NSF. This program could be a source of instrumentation for the field courses.

DISSEMINATION PLAN

Information developed during this project will be disseminated in print and electronic forms. The design of the field camp modules will be published in peer-reviewed journals in geoscience education. Publications on the design of hydrogeology field camps are scant (McKay and Krammer, 1999), with most of the literature being abstracts (Van der Hoven and Lenczewski, 2002; Repine et al., 2000; Ryberg, 1998; Shroder et al., 1998; Roberts et al., 1996; Benson et al., 1996; Saint and Maloney, 1989).

Information about field camp will be available in electronic form at several locations. Exercises will be available through the DLESE website (Digital Library for Earth Science Education-www.dlese.org). A website developed for the project will contain course materials, worksheets, and other instructional information. It will also contain photo documentation of the modules and field trips.

CUAHSI will also play an important role in disseminating information from the project. Equipment sets, educational portfolios and information required to operate hydrogeology field camps will be maintained by CUASHI as part of their Education and Outreach program, and they will coordinate the distribution of this material and development of other regional field camps.

EVALUATION PLAN

The quality and impact of the project will be evaluated by:

1. Peer Review. CUAHSI will coordinate both a summative assessments of the project by a panel of hydrologic scientists from its member universities. The panel will review educational materials, visit several of the classes, and provide recommendations for improving the course.

2. Pedagogic Assessment: Authentic assessment of pedagogical aspects of the course will be conducted by an independent expert (Kitts) during the second and third years of the project.

3. Formative Student Evaluations. Student evaluations of the instructors, instructional materials, and logistics will be obtained using questionnaires after each module.

4. Retrospective Evaluations: The course will be evaluated by soliciting retrospective evaluations from students and their employers or advisors 1 to 2 years after they complete field camp. This will be accomplished by sending the students and their employer/graduate advisor questionnaires about how the skills acquired at field camp have been used at their job or graduate research.

EXPERIENCE AND ROLE OF INVESTIGATORS

Larry Murdoch is an Associate Professor at Clemson University where he has taught or directed their hydrogeology field camp (http://www.ces.clemson.edu/hydro/FieldCamp/FC.htm) for the past 7 years. Dr. Murdoch will be responsible for the management of the project. He will be responsible for developing one of the modules, and will contribute to the development of several others. He will organize the pilot field course offered at Clemson.

Melissa Lenczewski is an Assistant Professor at Northern Illinois University and has been a co-director for the Environmental Field Camp at NIU/ISU for the last three years. Dr. Lenczewski will be responsible for developing several of the instructional modules, and she will oversee dissemination of course materials to be used in future regional field camps, such as the one at NIU/ISU.

Richard Hooper is the Executive Director of CUAHSI. He has overseen the growth of CUASHI to a national consortium with more than 100 members. Dr. Hooper will coordinate the development of the regional consortium who will teach the field camp, and he will organize the peer-review panel who will evaluate the camp.

Kathy Kitts is an Assistant Professor of Geology and Teacher Certification Coordinator at Northern Illinois University. Dr. Kitts is a former award-winning, certified secondary teacher who taught high school for ten years before returning for her Ph.D. and a university position. Dr. Kitts will assess the development of the modules according to best educational practices as outlined by the pedagogical literature (e.g. Bransford et al., 2000; Manduca et al., 2002 and Chiappetta and Koballa, 2002). She will function as an independent expert to ensure that each module includes authentic assessment components reflecting an evaluation of the activities performed by the students.

Senior Personal that will be responsible for development of some of the modules include: Stephen Van der Hoven (Illinois State University), Ron Falta (Clemson), and Ray Christopher (Clemson).

INNOVATION AND CONTRIBUTION

This will be the first major educational effort in the hydrological sciences taught by as a collaboration among a consortium of universities. The collective effort of the consortium promises to be a critical enabling factor that sustains state-of-the-art field courses in hydrologic sciences for the foreseeable future. Utilization of the CUASHI consortium will enable the involvement of faculty experts in particular techniques, which will ensure that the field course includes the best available pedagogical practices. Interaction among the faculty participants will provide a sustainable platform for faculty professional development in support of curricular adaptation and implementation.

Hydrology affects our quality of life by providing knowledge required to understand the myriad systems that depend on water. The roots of this knowledge lie in making and interpreting hydrologic field measurements. The project proposed in the previous pages will provide the intellectual and organization framework for ensuring the availability of excellent field training in the hydrological sciences. As a result, the project will contribute directly to the discipline of hydrology, and indirectly to society in general, by inspiring and strengthening the scientific backgrounds of the next generation of Earth scientists.

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