ACS Reform of Introductory Science courses for Non-Majors Course Mini-grants
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PROJECT SUMMARY: REDESIGN AND RE-IMPLEMENTATION OF *ENVIRONMENTAL BIOLOGY*

Environmental Biology is currently offered at Hendrix College as a non-science majors lecture course. The course addresses a wide range of issues, including biodiversity preservation, human population growth, pollution, global climate change, environmental triggers for emerging disease, the potential challenges and benefits of GMOs, sustainable development, and federal and international environmental policies.

However, the current course suffers from a lack of emphasis on the *process of science,* and how science informs policy decisions and drives the development of new technologies. The reforms proposed here include a semester-long series of field and bench laboratory experiences that will include hypothesis generation, experimental design, data collection, data analysis (including basic statistics) and the presentation of results and their implications.

The labs will examine human impacts on freshwater ecosystems in Arkansas. Students will study the history of water quality issues in the region, and then assess water quality at several sites. After learning basic water chemistry, fundamental ecological principles, and some natural history, students will be expected to generate testable hypotheses about water quality, aquatic vertebrate and invertebrate community diversity, and predicted resistance to environmental perturbation.

Because several of the freshwater sites considered for study are slated for either development or remediation in the next few years, the student results over successive semesters will also provide longer-term data on trends in environmental quality.

Last year, the College launched a campus-wide revision of the curriculum. The faculty voted to require that *all* Hendrix students take at least two courses in the Natural Sciences, one of which *must* have a concurrent laboratory.

Environmental Biology has traditionally been a very popular course with non-science majors. The lecture portion of the course will retain its discussion of current global environmental issues to ensure that students gain a basic understanding of (and functional literacy in) these important topics. However, the proposed implementation of a laboratory experience will provide a hands-on, question-driven approach to real local problems, fostering non-major students DOING science.

PROJECT DESCRIPTION

GOAL: To engage non-science major students in the scientific process by conducting a series of field and bench laboratories to investigate water quality as an environmental issue.

Objectives: Students will:

1) explore the history of each site tested and investigate the societal impacts and cultural contexts for changes in water quality;
2) conduct basic water quality assays, including water chemistry, clarity, flow and seasonality;
3) assess ecosystem diversity using algae, zooplankton, plants, invertebrate and vertebrate communities;
4) understand the concepts of endemism, habitat specificity, tolerance limits, and the dangers posed by introduced/exotic species;
5) generate hypotheses about population dynamics (competition, predation, etc.) and then design and conduct experiments in a controlled laboratory setting;
6) conduct basic statistical analyses to determine whether results are significant;
7) draw conclusions from the data, and discover what can (and can not) be concluded from a data set;
8) present the results so that others can understand them.

BACKGROUND AND SIGNIFICANCE:

The Environmental Biology course at Hendrix College currently offers non-science major students an overview of local and global environmental issues. However, the laboratory exercises proposed here will engage students in the scientific method as they gather data on water quality issues around the state of Arkansas that will form a long-term study of aquatic habitat health.

Arkansas, like most southern states, has a wealth of natural resources. While Arkansas' state motto is "The Natural State," its resources are increasingly under pressure from a growing human population and expanding development and agriculture interests. Each of the selected projects outlined below represents a potential environmental problem, but students will be challenged to determine whether the ecosystems and the communities that rely on them are actually at risk.

PROJECT DETAILS:

I.) Point-source pollution: impact of poultry farming on stream water quality. Arkansas leads the nation in poultry and egg production. Bacterial and nutrient contamination from chicken, cattle and swine operations in the Ozarks are threatening the pristine condition of many of the region's streams (Klugh and Rundl 2003, Petersen, et al. 2002). Poultry farms collect runoff from long poultry houses in holding ponds. After the particulate matter has settled, the pond water is returned via pipeline to the nearest watercourse. The sediment remaining in the pond is often used for pasture fertilizer.

Students will be introduced to the concept of *point-source pollution* and will investigate water quality with samples from a farm's holding pond, at the effluent discharge, upstream from the discharge and downstream from the discharge at varying distances. Students will be responsible for designing the sampling regime and conducting the tests. Basic field water chemistry kits will be used to assess pH, nitrites, nitrates, total nitrogen, sulfides, dissolved phosphorous, orthophosphates, and suspended sediment. Water samples will also be tested for dissolved oxygen concentration, plankton communities, and fecal coliform loads.

Students will also learn about the poultry farming business. In Arkansas, farmers own their poultry houses, but the birds themselves are typically owned by a much larger poultry processing corporation. Three farming families contacted have expressed willingness to have students test their facilities and talk with students about their livelihoods.

II.) Non-point source pollution and agrochemicals: The Delta region of eastern Arkansas is intensively farmed. Predominantly planted in rice and soybeans, most farmers routinely spray their crops with herbicides and pesticides. Students will learn about the different types of chemicals used in large-scale farming, and test field run-off for organophosphates and organochlorides. Additionally, they will design experiments to see if watercourses in the region have detectable levels of chemicals typically associated with farming. Students will also discuss the benefits and drawbacks of crops that are genetically-engineered to resist pests or herbicides.

III.) Drinking water safety: mine water, aquifers and dams. Coal, zinc, lead and bauxite mining booms between the 1880s and 1920s left abandoned mine shafts scattered across northern Arkansas. The mines have gradually flooded with ground water, and today, several communities are concerned that mine-tainted water has seeped into the aquifers from which they draw their municipal water supplies. In Marshall, Arkansas, the detection of high levels of strontium and other elements in the drinking water has spurred a movement to abandon the groundwater source and instead dam a nearby creek to build a reservoir (Petersen et al. 2002). Several environmental groups have sued the U.S. Army Corps of Engineers, claiming the project was not scoped with appropriate Environmental Impact Statements (EIS) in accordance with the National Environmental Policy Act (NEPA) (*Ozark Society et al., v. U.S.A.C.E.* 2001).

Students will test water quality from the municipal water supply in Marshall, as well as from a stream that flows out of an abandoned zinc mine. Students will be required to investigate what the potential health risks are, and whether the water meets federal standards for heavy metal contamination. Dr. Liz Gron, associate professor of chemistry, has offered to help students with the more sophisticated chemical analyses as part of her “Green Chemistry” program for her General Chemistry course. Her students will interact with the Environmental Biology students, explaining how atomic absorption technology works and testing the samples the students collect. Students will consider how standards for water contaminants are determined by the Environmental Protection Agency (EPA), and whether “detectable levels” written into law in 1970 have any relevance with the far more sensitive detection technology available today.

IV.) Community diversity in protected versus altered habitats: Students will design and execute a series of comparisons between a stream in a protected area with streams in areas with varying degrees of disturbance. The Strawberry River in northeastern Arkansas is part of a Nature Conservancy preserve, while nearby streams have been logged, either by selective cut or clear cut methods. Water chemistry and sedimentation, as well as community diversity will be particularly important. Students will be introduced to endemic (found *only* in that drainage) species of fish, crayfish and shellfish and learn some of the evolutionary principles that lead to species diversification. Some of these drainages also contain introduced species of crayfish (*Orconectes neglectus)* and shellfish (the Asiatic clam, *Corbicula flumine* and the zebra mussel, *Dreissena polymorpha)* that have been spreading aggressively in the last decade (Perry, et al. 2002, Robison and Buchanan 1988).

Students will study several different aquatic sampling methods (random transect, point-quarter technique, etc.) and decide which is best for addressing questions of community diversity. Standard ecological concepts of species richness and species evenness will be presented, and students will compare diversity values between study locations and determine whether there is a significant difference between them (Giller and Malmqvist 1999).

In order to determine the impact that introduced species have on native community structure, students will collect exotic and native specimens (with appropriate permits) and will design laboratory experiments to measure ecological interactions. Once students have established some parameters for predation, competition, etc., they will use these values to write a simple computer program. Using spreadsheet software, students can model interactions between species and predict how the community will respond under different population growth rates, densities, and competition coefficients (Donovan and Welden 2002).

PRIOR RELATED RESEARCH:

My own research focuses on the evolution and population genetic structure of darters and minnows in Ozark streams. I have worked with government agencies, poultry farmers, the Nature Conservancy, and other land owners. I am familiar with most aquatic sampling and statistical techniques, and have secured the help of chemists for more sophisticated analyses.

PROJECTED TIMETABLE:

The College has already determined the course schedule for the 2004-2005 academic year, so the course could not be taught with the proposed laboratory until Fall of 2005. However, *this* year is needed to prepare the materials and protocols for the course.

Time frame	Proposed Work
May – August 2004	Drive to all sample sites, secure student access and assess

	for student safety
September – December 2004	Prepare written materials for laboratory exercises, statistical analyses and computer modeling
January – May 2005	Trial runs of most proposed experiments with students in Natural History course (also non-majors)

CURRICULAR ROLE OF THE COURSE AND IMPACT ON THE INSTITUTION:

Hendrix College Faculty reviewed and revised the general education curriculum in 2001. The new curriculum requirements include at least one course that satisfies the "Challenges of the Contemporary World" requirement. Environmental Biology already is coded as a "CW" course. The implementation of the laboratory proposed here will make the course eligible for the "Natural Science with Laboratory Experience" (NS-L) designation. *Every* Hendrix student is required to take at least one NS-L course. *Currently, there are only two courses campus-wide with the NS-L designation that are designed for non-science majors.* Furthermore, the course is a requirement for any student majoring in Environmental Studies.

Currently, we teach 40 students per section without the lab. With the proposed laboratory, we would limit enrollment to 24 students per section, and would probably teach two sections in the Fall and one section in the Spring, bringing the total number of students to 72 non-majors per academic year.

EVALUATION, DISSEMINATION, AND CONTINUED SUPPORT

Assessing student achievement:

Environmental Biology instructors will use the FLAG (Field-tested Learning Assessment Guide) assessment tool developed under the auspices of the National Institute for Science Education, which was created and funded by the National Science Foundation. Students can complete the assessment tool online (www.flaguide.org), and the instructor can review and download analyses of student responses. These assessment tools are developed by education statisticians and the tools measure how students evaluate the various elements of the course according to how much they feel they learned from them. Instructors can use that information to modify the course.

Students in Environmental Biology are given *pre-* and *post-course exams*, with questions that cover scientific literacy, critical reasoning, designing controlled experiments, generating hypotheses, understanding the power and pitfalls of statistical analysis, and the limitations of the scientific method. The exam also includes a section assaying comprehension of science and technology issues in current events (i.e., stem cells, cloning, GMOs, emerging diseases, population growth equations, etc.).

Improvement in critical thinking skills can also be reflected in exams and writing projects throughout the semester. The course is writing-intensive, and although writing assignments are not easily quantified, they do provide valuable information on the development of the student's thoughts and analytical skills.

Dissemination of Results:

Students who have completed exceptional work may present their findings at undergraduate research conferences at other ACS schools. This spring, Spelman College is hosting an Environmental Conference—if that conference were to continue, it would be an ideal venue for students to present their results from the studies conducted in this course.

There are also several other opportunities to present the work, including the Arkansas Academy of Sciences annual meetings, as well as the National Conference on Undergraduate Research (NCUR). Hendrix College is usually well-represented at these conferences, and the College provides funds for travel and expenses for any student whose work is accepted for presentation.

Results from the entire class will be showcased at our annual Hendrix Research Day, as well as publicized on a website. Students will be encouraged to pursue publication in a peer-reviewed journal, if results are appropriate for submission. Because the Environmental Biology laboratory will actually be collecting data from several water sources each time the course is taught, there will be *within-semester* and *between-semester comparisons* of changes in water quality and community composition.

Continued Support:

After the initial purchase of field sampling supplies and reagents, the greatest cost incurred by the proposed Environmental Biology lab course will be the travel to study sites each time the course is offered. Although it is difficult to predict with absolute certainty, there is no reason to believe that the College would not continue to support a successful Environmental Biology laboratory experience for its students.

Environmental Biology is already part of the regular scheduled offerings, so no new faculty or adjuncts are required to teach it, but the laboratory component will need to be factored into the teaching loads of the faculty involved. Three other faculty members in the department have taught the course as a lecture, and all have expressed interest in incorporating a laboratory component. Because Hendrix College requires that *every* student take at least one laboratory course in the Natural Sciences, I predict the traditional popularity of the course will only increase.

Adaptability for other Institutions:

Freshwater stream water quality is an important environmental issue almost everywhere in North America. Many of the waterways across the southeastern United States, in particular, are facing pressures similar to those described for Arkansas (logging, damming, irrigation, aquifer depletion, mining and recreational development).

Most ACS-member institutions could adopt the protocols in the proposed laboratory for use in their own areas. Non-science majors at each institution can explore the history of water use in their area, and select sites for long-term study.

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