Using Active Inquiry in Undergraduate Oceanography Courses

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"Scientific Inquiry in Oceanography: Extreme Environments"

Developed for the Marine Biology Program, Rutgers University
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Summary

This course was developed for Rutgers University to fulfill two goals:

1. To teach undergraduates intellectual skills necessary for science: problem solving, hypothesis generation, critical review of primary literature, and scientific writing. The course mixed lectures, discussions, and reading and writing assignments based on research into marine extreme environments to achieve this goal.

2. To create a comprehensive, quality teaching experience for a team of four graduate students. A teaching workshop before the class began and a faculty mentor provided guidance on teaching strategies, and continuing evaluation from fellow graduate students, teachers and undergraduate students in the class provided input for improvement.

A. The Experience for Graduate Students

This course is designed to provide a team of graduate student Teaching Assistants (TAs) a complete teaching experience: under the guidance of a faculty mentor they choose the course theme and course materials, determine the class activities and assessments, and teach the course. Each TA is has the class for three meetings and is expected to incorporate a variety of teaching methods (lecture, group discussion, hands-on activities, etc.). Several aspects ensure that the TAs receive a high level of support and feedback:

- **Discussion Course in Teaching Methods**

The semester before the course begins, the TAs participate in a discussion group that reads and discusses articles on teaching methods (faculty from the Oceanography department also participate). Topics such as "designing a syllabus" and "leading a class discussion" are covered.

- **Peer Evaluation**

Each TA attends every class meeting, whether or not they are leading that class. After each class, the TAs meet to "debrief" and discuss what worked, what didn't, and how they could improve

- **Faculty Evaluation**

The faulty mentor attends classes as he or she is able to, and participates in the "debriefing" afterwards. For one class per TA the faculty mentor attends the class and completes a "Peer Evaluation", using the same form with which faculty members are evaluated. They later discuss this evaluation with the TA.

B. The Experience for Undergraduates

The course uses active-learning approaches to teach critical-thinking and scientific-inquiry skills to undergraduates. Specifically, students learn to:

- **Read critically**: identify hypotheses, consider alternatives, and find hidden assumptions
- **Synthesize complex, conflicting and incomplete data into a larger perspective**: explicitly consider how multiple threads of research are combined into larger theories and how different readings agree or conflict.
- **Identify logical future research directions**: develop hypotheses and ways to test them.
- **Consider the role of science in decision-making**: the integration of imperfect scientific information into societal decisions.

C. Course Design

The course meets once per week for 2 hours. Each TA is responsible for teaching a 3-week section; each section has a different topic but coordinates with the larger theme. Each year the theme and topics change as new TAs design the course. The syllabus from 1998, the first offering of the course, is given here as an example. The theme for this year was *Extreme Environments*.

D. Table 1: Summary of Class Activities and Content

Class	Assignment	In Class Activity	Topic Goal	Broader Goal
		Topic 1: Deep Ocean Circulation and Climate		
1	Individual reading assignment, brief oral presentation	20 min mini-lecture at start; presentations and discussion	Links between ocean circulation and climate	Synthesis of complex info into "larger picture"
2	Evaluate: "global warming will start the next ice age by shutting down deep ocean circulation." True? What information do we have supporting it? Conflicting with it? What critical information are we missing?	Course discussion to produce list of what information we lack for answering the homework question	Paleoclimatology via ice cores & isotopes	Scientific progression of moving from what is known to what needs to be discovered
3	Read and evaluate a mock scientific proposal	Mock proposal review panel	Proposal and grant funding process	Experimental design, finding primary literature in library
		Topic 2: Subsurface Microbiology		
1	Read 3 "Nature" articles with *conflicting* conclusion, answer "thinking" questions	Class discussion of thinking questions	The subsurface biosphere	Knowledge synthesis, understanding of science as "incomplete knowledge"
2	Reading on methods of sampling subsurface microbes from hydrothermal vents	Small groups evaluate method section from a real research paper; then class discussion	Hydrothermal vent chemistry/geology, deep-sea sampling methods	Real-world challenges of science
3	Write a proposal for research resolving a conflict/uncertainty in subsurface microbiology.	Individual peer-review of papers, group discussion of conclusions		"Creative" side of science – creating a research idea
		Topic 3: Estuarine Ecology		
1	Readings on estuarine ecology	Lecture on estuarine science	Estuarine ecology, physiochemical regime	
2	Reading on harbor dredging controversy	Class discussion of science and society (philosophical)	Estuarine management issue: dredging	Relationship between science and descision making
3	Write summary of two talks (post field trip)	Field trip to a regional Estuarine Science Research Meeting	Current topics in estuarine research	Exposure to primary research
		Topic 4: Nutrients and Ocean Productivity		
1	Reading; use ecosystem model to predict outcomes of perturbations	Lecture	Nutrient limitations in the open ocean	
2	Reading (individual assignments)	Class debate; small group discussion	Is iron a limiting nutrient?	Verbal skills
3	None	Small groups in computer lab build a Stella ecosystem model of an ocean gyre, use it to predict effects of system changes	Building computer models	Integrating information

"Case Studies in Environmental Data Analysis"

In Development for Environmental Systems, UCSD
K. Stocks, C. Peach, A. Withey

Overview

A new upper-level undergraduate course is in the early stages of development as part of a proposal submitted to the NSF National SMETE Digital Libraries Program on 4/17/02 (P.I. S. Miller, Co-PIs K. Stocks, P. Hastings, J. Helly, C. Peach, and B. Schottlaender). The overall project would create the *SIO Collections Gateway*, a web-based access and inquiry tool for the collections of the Scripps Institution of Oceanography (SIO).

The Collections Data

The four collections at Scripps (Marine Vertebrates, Benthic Invertebrates, Pelagic Invertebrates, and Geological Collections) collectively contain over 2 million specimens, each recording the latitude, longitude, depth and date when a particular species or sediment type was collected. Combined, these data can be used to explore the distribution of species over the oceans, the relationships between a species and its geological/physical environment, and how these patterns change over time.

The Gateway

The Gateway will be an online center with tools for finding, mapping, and analyzing data in the SIO Collections. It will be an extension of the NSDL-supported SIOExplorer system, and will have separate research-level and educational interfaces. For the educational interface, intuitive, graphic tools will allow students to ask "what do we know about *this* place", retrieving all information about samples there; or "What do we know about *this* species" retrieving and mapping data where that species has been found, linking to supplementary text and images about the ecology of that species, and connecting to a tool that analyzes how the distribution of that species might change with global climate change.

The Course

This course is being developed as a junior-year majors course through the Environmental Systems program at UC San Diego. Its primary purpose will be to prepare students to complete an independent research experience in their Senior year, moving them through the critical transition from *learning* science to *doing* science. Small groups of students will work together in this lab-style class to address a particular question in ocean science, e.g.:

- Where would you site a reserve to best protect the commercially and recreationally important rockfish?
- How would a hypothetical proposed sewage outfall affect the surrounding marine habitats?
- If the rate of nitrogen input into the coastal waters increased by 50%, predict the resulting change in the distribution of hypoxic waters and its effects on the distribution of bottom-living communities?

The students will identify the information they need to address their question (from the Gateway and elsewhere), collect that information, analyze and synthesize it, and finally present their findings in the form of a web page.