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Edited by
Sandra D. Buckner
and
Thomas A. McGrath

Conference Organizer
Vincent J. Voegeli

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LINKING RESEARCH WITH TEACHING: STUDENT PROJECTS AT THE GRC

Lynn Gillie, Robert Erdman and Todd Egan
Division of Mathematics and Natural Science
Elmira College
Elmira, NY 14901

ABSTRACT

A travel/field course in Marine and Island Ecology can be used to introduce science majors and non-science majors to biological diversity and ecological field methods. Mini-research projects in botany and zoology have been useful tools in guiding and assessing student learning. Students are grouped according to experience, with no more than one science major per group. Some examples of projects include systematic collections of plants, analysis of intertidal community diversity, and construction of behavioral time budgets. After data collection and analysis, students present results to their peers. With a few caveats, a mixed majors/non-majors course using student projects can be a success.

INTRODUCTION

An understanding of science is best acquired when students learn to do science themselves. Science majors and non-science majors should plan experiments, collect and analyze data, and subject their findings to peer review to begin to appreciate how professionals in scientific fields work. The chance to wrestle with a question and explore it experimentally is a real opportunity for cultivation of higher-order reasoning skills (Lawson, 1992). Many students attempt to conduct an experiment without observing and understanding the organisms on which they will be collecting data. The preliminary observations that are necessary to develop hypotheses and test them experimentally should be emphasized because of the tendency to overlook this preparatory step of the scientific method. Therefore, observational skills must be practiced and cultivated so that experimental design is more successful. The projects described in this paper rely heavily on acquiring observational skills before the data analysis and peer review can proceed.

THE COURSE

Organization

Marine and Island Ecology is a month long course offered each spring on San Salvador Island by science faculty from Elmira College and has been offered for nearly 30 years. This 6 credit course fulfills the general degree science requirement, and can be an elective for science majors. Terrestrial and marine ecosystems are studied with an emphasis on ecological techniques. Culture, history, astronomy, chemistry and geology are part of the curriculum, but the heaviest emphasis has been upon ecology. A combination of lectures, laboratories, and field trips make up the weekly schedule. Students keep detailed journals of their observations and experiences; the journals are collected and graded each week. Exams from each of the participating faculty are given every week as well. A multi-team scavenger hunt during the last weekend serves as a final practical exam. Participation in discussions, experiments, and fieldwork with a good attitude is part of the grade and is a necessary component of any field course.

Goals of the course are: (1) To introduce the scientific method to non-science majors, (2) To reduce the fear of science that many bring to the course, (3) To help students work with people with different opinions and viewpoints, (4) To provide opportunities to gain experience in careful, detailed observation, (5) To increase the level of sophistication that students use in their observational descriptions, and (6) To learn about the many adaptations of marine and terrestrial organisms on small carbonate islands.

The Students

Undergraduate students from freshman to seniors interested in registering for the course must submit an application. Participating faculty interview each student in a formal interview session. Students have an opportunity to ask questions and learn more about the class, and faculty can outline expectations. This seems to prepare the students for a rigorous course, and we have fewer problems and misconceptions as a result. The isolated environment, limited health care facilities, and need to respect others' culture can be emphasized in an individualized interview as well.

Students complete a series of small projects by collecting data, analyzing results and presenting their findings during parts of lecture, lab, and field time. Students are grouped randomly, and then reshuffled to ensure that the science majors are evenly distributed among the groups and to prevent clique formation. After a project is defined students decide what is to be done, and they divide up the workload among all group members. Typically, students choose to use their known strengths when offering to split the workload. For example, the science students organize the overall project and crunch the numbers, the art majors create the graphics, and the education majors present the data to their peers. Just as often, these stereotypical roles are shuffled among the group members so that their familiar and comfortable role is redefined, forcing students to broaden their horizons through necessity.

THE PROJECTS

Botany

Systematic Collections.

Students were introduced to the concept of dichotomous keys by preparing a key to the members of their class using morphological features, while being sensitive to avoid embarrassing anyone. Keying out random classmates tested the key. Further lectures taught students to how to identify plant families, identify common algae, and determine a plant's species using a dichotomous key. Once students were familiar with using a key, each student was required to collect 20 plant and/or algal specimens and identify them to family, genus, and species. Flowering plants and algae were identified using several field guides (Kass, 1985; Littler et al., 1989; Richardson and Mitchell, 1994; Smith, 1992; Smith and Amatucci, 1985).

Students were required to press plants/algae in standard herbarium presses and present them for mounting. Grading was based on a number of aspects including quality of specimens: were flowers or fruits present, was the specimen pressed correctly and dried, how detailed was the collection location explained, and was the specimen large or numerous enough.

Students enjoyed this exercise and had a feeling of accomplishment upon its completion. It was also evident that many students collected their plants together because many of the plant specimens and collection locations were common to all collections. Most points were lost due to incomplete location information, such as "plant was collected by students' dorm," "collected on San Salvador Island," or "found on road." It may be helpful to have students turn in half their plant collection midterm for feedback for the second half of the collection. This may help students avoid procrastination and encourage better labeling of locations. To help students better appreciate why systematic collections are important, further discussion of invasive plants, endangered species, common plant families of the tropics vs. temperate zones, transects and habitats of different species' locations, and island biogeography are all useful.

Zoology

Intertidal Zonation Studies.

San Salvador, like many islands in the Caribbean basin, has areas of rocky shoreline that are suitable for the study of the distribution patterns of intertidal organisms. This rigorous environment is subjected to daily cycles of exposure and submergence, and the inhabitants are faced with the concomitant problems of exposure, desiccation, and temperature extremes plus biological interactions such as competition and predation (Little and Kitching, 1996). Plants and animals that inhabit this area exhibit a variety of anatomical, physiological, and behavioral adaptations that permit their survival in this transitional area between the marine and terrestrial environment.

The intertidal zone on San Salvador is easily identified by the presence of distinct color patterns that run parallel to shore. Three separate divisions can be recognized: supralittoral (white, gray, and black zones), midlittoral (yellow zone) and sublittoral (lower platform) (Stephenson and Stephenson, 1950; 1972). This area provides students with the opportunity for firsthand observations of many organisms that are permanent inhabitants on rocks or in crevices, or are temporary residents of tide pools (shallow natural "aquaria").

Prior to conducting the field sampling students were introduced to the concepts of oceanic tides, benthic invertebrate foraging and feeding strategies, intertidal zonation, and factors that may influence spatial distribution patterns. Although the students had previously encountered rocky intertidal zones during numerous beach walks and entries into adjacent waters for snorkeling, it was apparent during the field study that few students had made anything but cursory observations of the inhabitants and conditions.

The study area was the rocky shoreline area adjacent to Dump Reef, approximately 1 mile east of the GRC. The limestone shelf comprising the intertidal zone is a good example of paleosol exhibiting the characteristic pitted and fractured surface typical of these exposed weathered rock structures. At low tide the intertidal platform ranged between 5 and 38 m in width.

Three transect sites were randomly selected along the shoreline. Metric tape measures and lines marked in one meter increments were used to establish transects perpendicular to the waters edge. Transects began at the extreme upper edge of the supralittoral zone (white zone) and continued across the intertidal platform (gray, black and yellow zones) and into the submerged lower platform. PVC grids measuring 0.5 meters on each side (0.25 m^2) were placed at each meter increment along the transect line and the inhabitants within the grid were counted and identified. For algae, individual organisms were not counted; however, percent cover was used as an estimate of abundance. Following identification and enumeration, all organisms were returned as close as possible to the original collection site.

Whenever possible, organisms were identified to species using field guides suitable for the San Salvador area (Diel et al., 1988; Kaplan, 1988.) Additionally, in order to better understand the possible effects of physical factors on distribution patterns, salinity, water temperature, and dissolved oxygen concentrations were measured in all tide pools encountered and in the adjacent coastal waters.

Data analysis for each transect included the calculation of species diversity and evenness using pooled data from each color zone (Table1). Kite diagrams were also developed that

Table 1: Summary data for rocky intertidal zonation transects.

Transect 1				
Color Zone	**Zone Width (m)**	**Number of Species (S)**	**Diversity (H')**	**Evenness (J)**
White	1.0	2	0.195	0.648
Gray	4.0	2	0.245	0.814
Black	4.0	3	0.461	0.966
Yellow	6.0	14	0.566	0.494
Lower Platform	7.0	10	0.462	0.463
Transect 2				
Color Zone	**Zone Width (m)**	**Number of Species (S)**	**Diversity (H')**	**Evenness (J)**
White	4.0	4	0.537	0.892
Gray	7.0	3	0.448	0.939
Black	3.0	4	0.505	0.839
Yellow	11.0	10	0.771	0.771
Lower Platform	3.0	4	0.285	0.473
Transect 3				
Color Zone	**Zone Width (m)**	**Number of Species (S)**	**Diversity (H')**	**Evenness (J)**
White	1.0	1	0	0
Gray	10.0	2	0.186	0.618
Black	4.0	5	0.495	0.708
Yellow	5.0	13	0.672	0.603
Lower Platform	8.0	10	0.778	0.778

Where: $H' = -\Sigma p_i (\log p_i)$ and $J = H' / \log S$

illustrated the spatial distribution patterns of each species across the entire intertidal zone.

Students were initially apprehensive when the diversity and evenness indices were presented as a statistical means to examine the data. However, after a thorough explanation of the steps involved in the calculations, they had little difficulty in organizing the data and completing the analyses.

The outcomes of this field experience were that students: (1) developed better observational skills; (2) became familiar with the use of field guides as a means to identify organisms; (3) became comfortable with the use of basic environmental monitoring equipment to take physical measurements, and (4) acquired the skills to analyze data using statistical and graphical methods. Additionally, students gained an appreciation of the rigors of the intertidal environment and the impact these factors have on the adaptations and distribution of organisms that inhabit this area.

Behavioral Ecology

Time Budget Construction.

A number of animal species exist on San Salvador that make good subjects for a behavioral study. Students are directed to choose a reptile, bird, or fish to observe. Anoles, geckos, northern mockingbirds, kingbirds, yellow-crowned night heron, blue tang, stoplight parrotfish, and various wrasses have all been successfully observed, and their behavior patterns described. Taxa that are useful tend to be diurnal or conspicuous, locally abundant, and engage in a variety of behaviors over a typical observational time period. Too many behaviors and students become overwhelmed; too few behaviors and students become restless, so careful choice of study animal is important.

Before students go into the field they create a list of all possible categories of behavior that they may observe in their particular animal during data collection. Clear operational definitions of particular behavior patterns are useful for replication of these studies by others. The necessity of an "other" category and an "out of view" category becomes evident after some discussion (Martin and Bateson, 1986). Categories are lumped together or subdivided as students see fit. To help students refine their categories, a discussion of the breadth and depth of typical behavior categories is conducted. Each student prepares a data sheet for a behavioral sampling method, usually focal animal sampling (Altmann, 1974). During focal animal sampling one individual is chosen for observation until the study is finished or the animal moves out of view. If the individual is no longer observable another of the same species is chosen and becomes the new focal animal.

An instantaneous sampling interval is chosen by the student. Slow moving animals can have longer sampling intervals than fast moving animals without sacrificing data. Locating the focal animal and recording its behavior every 30 seconds is usually a reasonable instantaneous sampling interval for general behavior patterns. Observed behavior patterns are thus recorded for 120 sampling periods over a one hour time frame, then extrapolated to a full 24 hours. The final product is known as a behavioral time budget, and is often graphically represented as a pie chart (Martin and Bateson, 1986).

Students learned about the influence of the observer on the study subjects; the importance of creating data sheets in advance; the patience involved in observing living things; and the uncertainty inherent in science. They were particularly frustrated when their focal animal ran, flew, or swam away, or stayed frozen in place for an hour. The adequacy of their operational definitions for the behavior categories became apparent very quickly when they tried to explain their data sheets to their peers. The struggle to design an appropriate study using an appropriate study subject was a great learning experience that may be more valuable than the finished time budget itself.

CONCLUSIONS

Most of the goals of the course were met by the end of the term. Both science majors and non-science majors alike learned to apply the scientific method to an environment that was new to most of them. Many of the non-science majors who had expressed a fear of science during the pre-trip interview said that they enjoyed the projects and learned a great deal from doing them. Journal entries increased in sophistication from the first week to the fourth week for both science majors and non-science majors, as their observations became more detailed and descriptive.

Working with people with different opinions and viewpoints was one of the biggest challenges for the students. As with all group projects, there were varying degrees of contributions from group members. Smaller groups, such as pairs of students conducting behavioral observations, tended to have fewer tensions than larger groups who had to divide the work among more members. However, the instructors rarely had to intervene in any group dynamics because the groups tended to self-regulate well. If there were problems, we did not hear about them until later, after they had been resolved by members of the group. Some science majors resented the attention that non-science majors received and felt that they and their skills were being neglected. Some felt they were not as challenged as they would have been in a majors-only course. However, many of the non-science majors did as well as or better than some science majors. During data analysis, non-majors contributed as much real work as the majors and contributed to the discussions. The unique environment helped level the playing field, as most students did not have prior experience with marine ecosystems. Overall, projects were useful to teach ecological methods as well as the basics of the scientific method, and students were interested and motivated during the course.

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