TWO BOATS, THREE SUMMERS, FIVE UNIVERSITIES, ONE DOZEN INSTRUCTORS, AND SIXTY-FIVE TEACHERS: A COLLABORATIVE OCEANOGRAPHY FIELD PROGRAM FOR EARTH SCIENCE

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Abstract

A three-day field workshop was an integral component of the graduate-level course entitled, *Oceanography*, that was offered by Virginia Earth Science Collaborative Project (VESC) to help Virginia educators earn the earth science teaching endorsement. The VESC partner institutions that offered *Oceanography*—George Mason University, James Madison University, the University of Virginia Southwest Center, and Virginia Commonwealth University—lacked direct access to research and education facilities on the coast. The College of William & Mary, another VESC partner, provided this resource through the Virginia Institute of Marine Science's (VIMS) Eastern Shore Laboratory in Wachapreague, Virginia. The field program agenda and activities were developed and conducted by a team comprised of VESC oceanography faculty, Virginia Sea Grant educators, and a scientist from VIMS. This collaboration resulted in a program design used as the basis for six workshops conducted over three summers. Seventy-nine Virginia middle school and high school science teachers took part in the six workshops, conducted in July of 2005, 2006, and 2007. This article describes the workshop activities and provides perspectives on its design and implementation from the viewpoints of Virginia Sea Grant educators who served as field instructors.

Description of the *Oceanography* Field Workshop

The importance of authentic research in the professional development of science teachers has been recognized for some time [1]. Studies of the preparation of earth science teachers in particular suggest that field experiences provide a foundation for learning concepts that cannot be taught adequately in a classroom-only environment [2]. In addition, earth science teachers report that they believe they can teach a concept better when they have had first-hand experience, and are able to see how it relates to teaching standards [3]. In multidisciplinary earth sciences like oceanography, it is particularly important that teachers engage in field inquiry in order to experience the real-world connections among concepts, research methods, and data.

The field workshop which is the focus of this article was a component of the 4-credit, graduate-level *Oceanography* course designed to provide Virginia teachers with one of the science courses required for endorsement to teach earth science. *Oceanography* was one element of a larger project ("Developing Highly Qualified Earth Science Teachers") designed and conducted by the Virginia Earth Science Collaborative (VESC), a partnership of nine institutes of higher education, non-profit organizations, and more than seventy school divisions. Funding was provided through a competitive Mathematics and Science Partnership (MSP) grant funded through the federal No Child Left Behind legislation of 2001.

Oceanography was taught at George Mason University (2005), James Madison University (2005–2007), the MathScience Innovation Center (formerly the Mathematics & Science Center) through Virginia Commonwealth University (2006), and the University of Virginia Southwest Center in Abingdon, Virginia (2007). The Virginia Institute of Marine Science (VIMS) held an oceanography field workshop for each course. The instructional team for the field workshops was comprised of three marine science educators (Vicki Clark, Dr. Carol Hopper-Brill, and Christopher Petrone) from the VIMS-Virginia Sea Grant Marine Advisory Program. During the first and second years, the VIMS team also included a scientist from the VIMS Department of Biological Oceanography, Dr. Rochelle Seitz. The field workshop was developed by this team, collaborating with the faculty instructors from the VESC universities and staff at the VIMS Eastern Shore Laboratory (ESL). Each workshop took place at the VIMS Eastern Shore Laboratory.

Goals and Objectives

The primary goal of the field workshops was to support and extend the *Oceanography* lecture and classroom activities that were conducted at each of the partner university sites. The field component provided additional oceanography content, introduction to current scientific research in the Chesapeake Bay, and practice in field data collection methods in the unique surroundings of Virginia's Eastern Shore. The major objectives of the field workshop, in order of emphasis, were the following:

- Increase participants' content knowledge of selected oceanography concepts and topics (currents and tides, barrier island geology, ocean beach and tidal marsh habitats, marine invertebrate and fish ecology, human impact, and current environmental issues on Virginia's Eastern Shore);
- Provide Virginia science standards-based models of field, lab, and classroom activities that teachers could adapt and implement with their own students; and,

- Introduce teachers to on-line and other resources for teaching oceanography concepts with scientific data.

Description of Facilities

The Virginia Institute of Marine Science (VIMS) is the School of Marine Science of the College of William & Mary. VIMS is a research and teaching facility providing research, education, and advisory services related to Virginia's marine and estuarine resources. The Virginia Sea Grant (VSG) program, one of the National Oceanic and Atmospheric Administration's National Sea Grant programs, is located at VIMS. The VSG education team currently conducts ocean research-based educational programs for grades 6-12 educators and students, develops and disseminates teaching materials, and provides a liaison between the research and education communities.

VIMS's Eastern Shore Laboratory (ESL), the site of the *Oceanography* field workshops, is located on approximately four acres in the coastal fishing village of Wachapreague, Virginia. The campus includes a small residence lodge and a 3,200-square foot building which supports visiting researchers and students with a classroom and a teaching laboratory. The ESL has a fleet of small, shallow-draft vessels which provide access to estuarine and near-shore ocean habitats along the seaside and bayside of the Eastern Shore. The ESL vessel operators have extensive knowledge of local waters, field sites, and regional flora and fauna. They serve not only as boat captains, but as guides, teachers, and safety personnel.

Field Workshop Activities—Data Collection and Observations

The field experiences were designed to provide an overview of the Eastern Shore coastal environment, with a focus on the basic physical, chemical, geological, and biological parameters that define each habitat (see Table 1). Field trips were scheduled around low tides, as some habitats, such as mud flats and barrier island beaches, are inaccessible at high tide.

Table 1
Brief Overview of Six Field Sites, Including the Activities Conducted and Rationale

Location	Field Activity	Focus of Exploration
Nickawampus Creek	Dredge, trawl, measure phys. & chem. water quality	Benthic (bottom) and mid-water fauna; dynamics of tidal marsh creek
East Wye Mudflat	Sediment sampling, measure phys. & chem. water quality	Mudflat (surface and below) and associated organisms
Clubhouse Point	Trawl survey of lagoon, measure water quality	Lagoon channel, sediments, water quality, organisms; comparisons with ocean and creek
Cedar Island	Barrier island transect and beach seining	Variation in elevation, habitats, and organisms across a barrier island; comparisons with Parramore Island
Parramore Island	Barrier island transect	Variation in elevation, habitats, and organisms across barrier island; comparisons with Cedar Island
Wachapreague Inlet	Depth transect, measure current and phys. & chem. water quality	Variation in inlet depth; currents and tides
Coastal Atlantic Ocean	Trawl survey of near-shore open ocean, measure water quality, and currents	Coastal ocean organisms and currents

Teachers were divided into two research teams and assigned to different boats. Each vessel held ten to twelve people with gear. The crew included a boat captain and instructors.

The boats carried similar instrumentation and equipment, including a YSI (Yellow Springs Incorporated) electronic water quality meter, water sample bottles, refractometer, thermometers, binoculars, trays and acrylic “view boxes” for observing live organisms, and shovels, rakes and core samplers for mud flat exploration. In addition, each boat was equipped with some gear not found on the other (plankton net versus trawl net; benthic grab versus oyster dredge). Teachers rotated between boats to ensure they had the opportunity to use all types of equipment available. Both boats visited the same collection sites simultaneously. Teams from

the two boats recorded data on waterproof data sheets. At the end of each field day, they shared their findings, producing a daily data report.

Field Workshop Activities—Observations and Sampling

It is widely accepted that the use of authentic marine life specimens, whether live, preserved or prepared, is vital to effective teaching of marine biology and ecology topics. Teachers and students need to be exposed to actual specimens as a means to accurately identify species, to build familiarity and respect for biodiversity, and to study marine life anatomy, form and function, lifestyle and behavior. However, indiscriminate collection, stressful handling, and poor maintenance of living specimens should not be modeled as professional behavior. The workshop orientation activities included a discussion of the importance of environmentally responsible collection and handling techniques, emphasizing respect for the organisms used as teaching tools. The goal was to promote awareness of the ecological services these organisms perform in their natural environments. These techniques were practiced throughout the field collection and laboratory activities.

Field Workshop Activities—Laboratory

The laboratory was used as headquarters for sorting and identifying samples collected in the field. In addition to standard teaching lab equipment that included microscopes, dissecting kits, field guides and dichotomous keys to organisms, the lab was equipped with several computer workstations with Internet access to assist in research. Each teacher also had a wireless laptop computer, loaned for the workshop by VIMS. LaMotte brand water chemistry test kits were used to analyze water samples. Dockside flowing seawater tables and small, ten- to twenty-gallon aquaria in the lab held live samples for temporary observation. Live organisms were released at the end of the workshop. A major activity was the compilation and comparison of data from the two different field teams. Computers greatly facilitated this activity, and at the end of the day, each participant was provided with a digital copy of a summary data report and an image bank of field photos.

Practicing Laboratory Protocol

The field course offered an ideal venue for introducing or validating professional behavior in both the laboratory and field settings. Course instructors explained and modeled responsible scientific practices, and encouraged the teachers to promote similar skills and ethics with their students. In their classrooms, teachers often struggle to teach students how to take care of shared scientific equipment and clean up after lab activities. The roles are reversed when the teachers become the students. At the ESL, teachers shared the lab space with several ongoing

research projects. Workshop instructors described the research projects and explained lab protocols designed to prevent use conflicts between the researchers and the teachers. Working daily in close proximity naturally resulted in numerous conversations among teachers and researchers about the scientists' (and teachers') ongoing work. This was a small, but valuable part of the workshop activities.

Three Summers Later: Lessons Learned

The *Oceanography* field workshops validated and reinforced the field instructors' experiences regarding what science teachers appreciate in professional development programs.

- Experiences in the natural environments related to the subject they teach.
- Time spent with experts in the field.
- Workshops that are conducted in an authentic scientific setting.
- Workshops that provide resources for their classroom instruction.
- Workshops that allow opportunities for interaction with other teachers.

During the course of this three-year collaboration, the field instructors modified several areas of the field workshop based on direct observations, discussions with the university faculty, and interviews with and written feedback from participants. These "lessons learned" inform three components of the program:

1) Collaborative planning, organization, and communication;
2) Fieldwork and other instructional activities; and,
3) Participants' overall experience.

Lessons Learned: Collaborative Planning, Organization, and Communication

One of the challenges of team-taught and collaborative courses is assuring continuity and articulation between classroom content and field exercises in the professional development experience. After the first year of the oceanography collaboration, greater articulation between faculty and field instructors' instructional planning was established from experience and the identification of gaps and issues through the program evaluation. We found that the following practices strengthened the collaboration and provided a more optimal experience for participants.

Early planning, in addition to frequent and detailed communication between university and field instructors, led to a more coherent integration of science content, and field research and observation. For example, when faculty instructors wanted to emphasize particular oceanographic concepts or personal research topics in the field, communicating these objectives

to the field instructors and lab staff early in the planning process allowed the field staff time to incorporate them in a more cohesive manner.

During the first summer, much of the field trip information for the teachers consisted of handouts and e-mail passed from the field instructors through the faculty instructors. Based on the teachers' comments after the first summer, field instructors and faculty set up a more open and interactive system of communication. A combination of direct e-mail messages, face-to-face meetings when time and distance allowed, and individual communications as needed between field instructors and the participants contributed to better teacher preparation for the fieldwork. In particular, the on-line interactive course management system, *Moodle*™, (maintained by the MathScience Innovation Center instructors for their course in 2006) provided a useful tool for advance planning and communications. The proportion of participants who felt they had received adequate advance communications about preparing for the workshop improved from 50% in 2005 to nearly 80% in 2006.

During university classroom instruction, teachers received background on scientific methods and protocols for collecting and analyzing observations and data. This helped prepare them for the field experience, building familiarity with instrumentation, types of data to be collected, and how the data reveal basic concepts covered in class.

Faculty clearly communicated the course evaluation metrics, especially the relative weight of the field experience and the final reports in the final course grade. Participants' final reports and projects based on the field experience were presented and discussed in the university classroom. This gave the teachers time after the field trip to reflect on and discuss what they learned, and how it applied to their classroom instruction.

Lessons Learned: Field Instruction and Workshop Activities

As with any scientific expedition, appropriate preparation and outfitting have a significant impact on the success of the venture. For many teachers, the field workshop was a novel experience not just from a scientific standpoint, but from a logistical one as well. Helping teachers anticipate and prepare for a novel experience in the field by providing plenty of detailed information in advance is critical to the confidence, safety, and comfort level of the participants. Instructors must recognize that many teachers have limited experience working outdoors, and they may not know what clothing and supplies are appropriate. Teachers received information and photos via e-mail about accommodations, fieldwork conditions (weather, insects, water, safety, etc.), and the regional environments. A *PowerPoint* presentation made during the first

year's workshops was used to introduce the second- and third-year teachers to the experience. Many teachers noted that this visual instruction was particularly helpful. The packing checklist provided to them weeks before the field event was also mentioned many times as a very helpful resource.

Instructors should be aware of confidentiality laws regarding personal medical information, but participants should be encouraged to communicate with instructors about physical limitations, allergies, or other medical circumstances that require advance preparation and diligence by the ESL staff and field instructors. For example, several participants in the *Oceanography* workshops had somewhat limited mobility, but the boat captains were able to make minor changes in operations, such as arranging for the use of a floating dock for boarding and unloading passengers, which made their participation possible.

The novel outdoor working environment presented not only physical, but mental challenges. Instructors soon recognized that teachers, like younger students, were somewhat overwhelmed by the barrage of stimulating sights, sounds, and activity inherent in a field experience. It is difficult to process and retain new, detailed content while in the field. The schedule was adjusted to increase time for laboratory analysis and classroom discussion each day. Group discussions to review content, and discuss meaning and classroom applications helped teachers build context for new experiences and new knowledge.

One of the most difficult continuing challenges for the field workshop instructors is distilling the field experience into the limited time frame of three days. Instructors were originally somewhat unrealistic about what could be physically accomplished each day. The field time was subsequently shortened by reducing the number of field sites, choosing only those that provided distinct habitat contrasts.

Many teachers seemed more interested in the living organisms as opposed to the physical and geological features which are emphasized in the "Earth Science" section of Virginia's *Standards of Learning* [4]. Instructors used this interest in the biological elements by frequently framing the study of the physical, chemical, and geological factors as important impacts on the biological community composition. Over the course of the three years of workshops, instructors moved from time consuming laboratory analysis that involved detailed identification and cataloging of all species, to a simple biodiversity index activity. This activity required the teachers to sort and identify organisms only to phylum and class level, indicating the number of different kinds observed in each group. This index provides a framework that can be used for a

variety of comparisons from habitat to habitat, including applications to data collected in the schoolyard by students.

Demonstration of how the teachers could apply their new science skills and data sets in their own classrooms became a bigger part of the field workshop during the second and third years. Although the original design of most of the *Oceanography* courses in this project emphasized science content over pedagogy, teachers expected more than facts and fieldwork from the course. They wanted to see the basic principles they learned in class illustrated through the fieldwork, and they asked for specific examples of lesson plans incorporating oceanography concepts and their field experiences and field data. After the first year, faculty and field instructors allotted more time in the syllabus to demonstrate and discuss lesson plans and activities that the teachers could use or adapt. For future courses, if the desired goal is to focus strongly on science content to improve the teachers' basic knowledge rather than to demonstrate teaching applications, course marketing materials will specifically note this emphasis. Otherwise, many teachers will assume that professional development courses will include pedagogical applications (i.e., "lesson plans") and most university science faculty are not prepared to provide this approach.

The teachers sometimes needed guidance in translating the content, methods, and data from the field experience to teaching activities relevant for use in their classrooms. After the first summer, instructors increased the number of examples of lesson plans, case studies, field trip ideas for the teachers' local area, and classroom activities using field data and methods. The field workshop provided the participants with a large body of scientific data, including many digital images. In several of the classes, the teachers developed "virtual field trips" for their students, using these data and other resources from the field experience. Follow-up reports from the teachers indicated that these digital field trips were extremely motivating and attractive for their students.

Lessons Learned: Participant Experience and Feedback

The statements in the following section reflect comments received from the teachers on post-field workshop questionnaires administered to all participants, and in focus group interviews conducted by a VSG educator who was not otherwise involved in the project.

Teachers clearly enjoyed the range of experiences offered in the field workshop, but they consistently noted that they needed more time to absorb content, process data, or just rest. Teachers had the following recommendations: decreasing the number of field sampling sites;

simplifying the biological classifications; eliminating classroom lectures; and, practicing better time management through a division of labor by assigning different data analyses to different teams. Other teachers, however, strongly preferred to be involved in the collection and analysis of all data.

While many teachers clearly appreciated the discovery-learning aspects of field science, several wished for an increase in overall structure, including more direct and detailed assignments of duties to the field data teams, and more advance discussion of how the data would be collected. Some even suggested checklists of what they would see in the field and what they were expected to learn. Some of these requests reflect the teachers' anxiety about how the field experience would be included in the final course exam. After the first year, the teachers' concerns were somewhat alleviated by a clearer definition of how fieldwork would be graded.

Teachers also requested specific information on the relationship of field activities with the Virginia *Standards of Learning* (*SOL*) [5]. This suggests that some teachers perceived the field workshop less as a scientific discovery experience for their own personal knowledge than as a potential pedagogical model for their classroom teaching. This expectation was also expressed in the teachers' requests for more classroom-ready, hands-on, *SOL*-aligned activities. Teachers' expectations that classroom pedagogy and instructional resources would be included in what was largely a content-based field experience indicates that they would benefit from additional guidance on making connections between oceanographic concepts and Virginia's oceanography curriculum and related *Standards of Learning*. As noted in the previous section, the instructors responded during the second and third summers by including more specific examples of oceanic, data-based lesson plans and activities, such as "The Bridge," a marine education center co-sponsored by Sea Grant and the National Marine Educators Association [6]. Additionally, if future *Oceanography* courses could include a follow-up workshop focusing specifically on oceanography teaching methods and resources, this would improve the likelihood that teachers will apply the knowledge, data, and other resources they gained from the field experience to their own classrooms.

Summary

The field workshop provided an immersion experience for the teachers, field instructors, and university faculty. Teachers and faculty were involved directly with the oceanography concepts, scientific instrumentation, data collection, and the coastal habitats they had been learning and teaching about in class.

Participating teachers overwhelmingly valued the access to diverse coastal environments. They appreciated the opportunity to practice hands-on science in an authentic setting, to develop familiarity with oceanography equipment and use it to collect data, and to examine samples first-hand in the laboratory setting. They also valued highly the access to marine scientists and their expertise, and the "insider's" view of marine scientists' passion and process.

Field instructors were challenged in some instances with introducing the faculty as well as the science teachers to the complexities of the Eastern Shore coastal environment. As both faculty and field instructors gained experience and got to know one another, their increased collaborative planning and teaching efforts began to yield very positive results. This project has led to a more integrated and instructionally rigorous syllabus for future *Oceanography* field workshops. ■

References

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