Merging Marine Science and Engineering in the Classroom
By Karen Neely

Over 2500 years ago, before the invention of sliced bread or even the invention of the baker, before the founding of Paris or London, before the European discovery of the Americas, the exploration of our oceans was underway. Though accurate time keeping devices and charts were centuries away, inventions and engineering feats were allowing for navigation upon the waters. Entering an unknown world, where landmarks were non-existent and there stretched before sailors "miles and miles" of "miles and miles," marine engineers began to develop tools for measuring the unseen mysteries below the waves.

One of the first of these tools was the Egyptian-invented lead line. Thrown overboard, this weighted line could provide an approximate depth based on the time elapsed before hitting bottom. Through the centuries, this simple tool was continually modified so as to be more useful. Marks were added to the line to improve the accuracy of measurement. A lump of sticky wax was included to allow substrate sampling. Eventually sonar, computers, and LCD screens replicated the tool and became known as depth sounders. But in every form and every century, the invention has been essential in navigating, sampling, and exploring a world that is rarely seen without technological assistance. Lead lines traveled in boats ahead of Captain Cook as he navigated through Australia's Great Barrier Reef. Depth sounders accompany modern vessels in their searches for wrecks and underwater ridges. Even literature's Samuel Clemens was struck by the calls of the Mississippi's "leadsmen" and developed his pen name after the two-fathom depth call: "By the mark, twain!"

Invention and design have been essential in all aspects of ocean exploration. Boats themselves, through the design of rudders, sails, and propellers, are the culmination of centuries of engineering genius. The harvesting of resources from the ocean has posed endless challenges never encountered on land. Engineers, often under the names of "artisanal fishermen," "New Bedford whalers," or "oil rig technicians," have changed resource harvesting from a world of fibrous nets to a world of self-contained factory ships and mile-deep mineral extraction. More recently, engineering has proven itself essential in improving marine research and conservation. Satellite tags, remotely operated vehicles, SCUBA gear, and remote sensing all make it easier, safer, and cheaper for both scientists and the public to go deeper, observe better, and measure more accurately.

The integration of these inventions into scientific research is often made possible by the federally-funded National Science Foundation (NSF). Since President Truman created the agency in 1950, NSF has funded endeavors in all branches of science and produced more than 100 Nobel Laureates. Presently, more than 200,000 students, teachers, and researchers are involved in projects funded by the more than $2 billion distributed each year.

In 1999, forty-nine years after it was established, NSF created a new funding program for non-research projects. Concerned about the loss of science in K-12 curricula and the increasing divide between scientists and the public, a new initiative was launched to bring science back into schools and to incorporate scientists themselves into the classroom. Former NSF Director Rita

Colwell remarked, “We cannot expect the task of science and math education to be the responsibility solely of K-12 teachers while scientists, engineers, and graduate students remain busy in their universities and laboratories. There is no group of people that should feel more responsible for science and math education in this nation than our scientists and engineers and scientists- and engineers-to-be.”

Following this philosophy, up to $20 million has been allocated annually for the creation and continuation of partnerships between universities and K-12 schools. Each combination of researchers, teachers, and administrators is tasked with the integration of graduate and undergraduate students into K-12 classrooms as science, technology, engineering, and math specialists. Programs are each provided $660,000 a year to fund student stipends, resources and materials, field trips, and teacher opportunities. By 2003, 101 partnerships had been established, 1001 university students had gained teaching experience, 976 classrooms had received scientific expertise, and 29,280 K-12 students had met and learned from young scientists (Figure 1).

While these education-based grants are available for math, engineering, social science, and physical science partnerships, many of the programs have centered on marine science. One of these, a collaboration between the Duke University Marine Lab and the Carteret County Public Schools, has put thirty three graduate and undergraduate students into six K-12 schools. With each student comes a knowledge of oceanography, marine organisms, and marine policy. Also included are wide-ranging experiences and interests, the tangible and intangible resources of the student and the university, and bountiful enthusiasm. The partnerships aid university students by improving communication and teaching skills, K-12 teachers by providing resources and in-class science specialists, and K-12 students by improving the quality and quantity of science education. Studies of the program have shown evidence of improved test scores, improved participation in science fairs, greater interest in pursuing collegiate and scientific interests, and increased classroom time on math, science, and hands-on activities.

While the results of these studies encourage NSF to continue funding new partnerships, established projects continue to expand. As initial infrastructure, recruiting, and supply problems are overcome, existing partnerships, often aided by NSF’s “supplementary funds,” have become increasingly interdisciplinary. Two programs in North Carolina—the Duke University Marine Lab’s “Scientists in Schools” and the Duke University Pratt School of Engineering’s “MUSIC: Math Understanding through Science Integrated with Curriculum”—partnered this year to combine marine science and engineering into K-12 lessons. Though separated by discipline and by 150 miles, the pairing of these programs has led to the development of interdisciplinary activities teachable to both coastal and inland students.

The partnership facilitates a series of planning workshops which allow graduate students from each program to use their experiences and expertise to both brainstorm engineering solutions to marine science problems and to develop K-12 lessons combining the two disciplines. The initial workshop, held in February 2004, culminated in the production of four lesson plans and six activities, all of which merge engineering and marine science principles (Figure 2). One lesson introduces students to the problems of marine bycatch and addresses potential technological solutions such as acoustic pingers and turtle excluder devices. Another lesson examines both the environmental and engineering aspects of oil spills through activities on buoyancy, research on ecosystem impacts, and the clean-up of a model coastline. A third lesson addresses bathymetry mapping by sampling a model ocean using lead lines and learning the practice and applications of operating depth sounders and side-scan sonar. A fourth lesson examines the science of animal tracking through an overview of tagging projects and the designing of a tracking and sampling device. Each lesson addresses not only engineering and marine science principles, but also numerous mathematical and analytical skills.

Whether achieved through NSF's K-12 Program or through external efforts, the combination of the marine science and engineering disciplines has many benefits. Teachers are encouraged to expand their interests and develop innovative lessons on today's important issues, and students are empowered to gain an understanding of the problems their generation will be expected to solve and to develop the thought processes and skills to formulate those solutions.

Partnerships funded by NSF must be formally submitted by a university researcher, but are often initiated by K-12 educators. For more information and application details, see the NSF website at www.her.nsf.gov/dge/programs/gk12.

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Figure 1: Map showing locations of NSF-funded partnerships between universities and local schools.

Figure 2: Duke students Vicky Thayer, Matt Nusnbaum, and Amy Whitt work to develop a fisheries bycatch lesson incorporating both marine science and engineering components.

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