# Training Ocean Engineers for the Twenty-First Century

***Andrew Clark***
*Harbor Branch Oceanographic Institution*
*Fort Pierce, Florida*

No definitive treatment on the subject of ocean engineering education would be complete without addressing the program at Massachusetts Institute of Technology (MIT). That MIT as well as a number of other institutions' programs of excellence in ocean engineering (see Table 1 in Dunn and Smith's paper) do not appear in these pages simply proves that this is *not* a definitive work, nor has this been the intent. Quoting Woods Hole Director Craig Dorman in *Oceanus*' superb 1990 issue on Marine Education, "we make no attempt to be complete. Our interest is in giving you a feel for the range of activities and perspectives on the subject." You might think of this as Volume I of a series. In true academic tradition, I leave *the derivation (of additional volumes) as an exercise to be completed by the reader.* I can guarantee that anyone who rises to this challenge, to pick up where I have left off, will—notwithstanding deadlines—experience a tremendously rewarding and amusing excursion among the intelligentsia of marine technology. This is an area whose very nature has drawn some of the most brilliant and interesting characters extant. In addition, marine technology as a field is sufficiently young that most of its "founding fathers" are not only still among the living but also among those still actively making significant contributions. Adhering to my precedent for being incomplete, I solicited the viewpoints of some (not all) of these pioneers in pulling together this Introduction.

## WHO? AND WHY?

Each of the contributors to this issue represents a different approach or perhaps a different piece of an overall approach to a solution. The problem, of course, is how best to train ocean engineers for the future. The papers that follow represent a diversity of methods on both how and when to prepare ocean engineers.

The first paper is a contribution from Florida Atlantic University, where programs are offered for bachelor of science, master of science, and doctorate degrees in ocean engineering. A compelling argument is made for the need of each of these three levels of education.

The second paper describes the approach taken by the U.S. Naval Academy, where, due to the unique charter of that institution, ocean engineering education is limited to an undergraduate program. Highly specialized training is provided for a job that, the author points out, is guaranteed to each graduate.

In the third paper, the authors submit that the University of New Hampshire upholds the philosophy that ocean engineering should be undertaken at the graduate level. While the university offers only a master's degree in ocean engineering, its undergraduate programs in other engineering disciplines allow for a minor in this area.

Following this paper, we learn from the University of Hawaii that, after offering an ocean engineering program exclusively at the graduate level for over twenty-five years, they are now developing an undergraduate program. The University of Hawaii currently has programs for both master's and doctorate degrees in ocean engineering.

Next is a contribution from Texas A&M, a university that for years has offered both graduate and undergraduate ocean engineering programs but, in periods of low enrollment, has considered discontinuing the latter. Rather than discuss either of these programs, however, the author devotes the fifth paper to describing a joint program between Texas A&M University and the University of Texas. This program is bringing undergraduate students enrolled at institutions that do not have programs in ocean engineering to the Offshore Technology Research Center for intensive ten-week internships.

Few need a reminder that graduates in any field of study are entering an international market place. The pages of each volume of this journal are replete with the global issues that face us, and thus they will not be repeated here. In this vein, included here are two articles intended to provide an international perspective. First, it would seem that no discussion today of where the United States ranks internationally can be concluded without a comparison with Japan. Indeed, in my less than scientifically conducted opinion survey, Japan, along with the United States, was unanimously ranked as a leader in making consistent, significant technological contributions as well as in providing superior education programs in ocean engineering.

The contributing authors from Japan's Research Institute of Ocean Economics have compiled a report that provides insight to the overall education infrastructure in Japan and the national emphasis placed on ocean engineering as well as marine sciences and resources. This report provides not so much detail regarding how their ocean engineers are being trained, as it does how many. Additionally, it is interesting to note that, according to the most recently compiled figures of the Institute of International Education, in 1990 students from Japan made up a full 9 percent of all foreign students enrolled in U.S. universities (second only to 9.7 percent from China).

The second international article is actually a synopsis of a report compiled by the Working Group on Ocean Engineering Education sponsored by Canada's Engineering Committee on Ocean Resources (ECOR). The findings of this group of experienced ocean engineers from national laboratories in Nigeria, India, South Korea, and The People's Republic of China focus on the need to provide working engineers continuing, targeted training in ocean engineering, long after they receive their degrees.

The final commentary in this issue represents the other end of the educational spectrum. Recognizing the importance of kindling interest in future ocean engineers and scientists earlier even than the undergraduate level, the author describes Project Marine Discovery, a pilot program aimed at reaching students from kindergarten through twelfth grade. The program, cooperatively sponsored by the Gulf Coast Research Laboratory and the Mississippi-Alabama Sea Grant Consortium, is intended to introduce the participants to marine science and technology through hands-on experience. No doubt, this program is helping to focus now the ambitions and energies of tomorrow's incoming class of ocean engineers.

## WHAT?

By now it should not come as a surprise to the reader that there will be no attempt made here at providing the penultimate definition of ocean engineering. Further, others have done an adequate job at this elsewhere. The reader is referred to an article in the *Marine Technology Society Journal*, Volume 11, Numbers 5 and 6, pages 33 to 35, entitled "What is an Ocean Engineer?" by J.W. Schwalbe of Florida Institute of Technology. While it may be difficult to provide an exact definition of ocean engineering at any given point in time, this is probably unnecessary. Perhaps it is better to recognize this area of endeavor as one whose shape is in a constant state of change. As a result, a "snap shot" taken at any instant will exhibit some fuzzy boundaries. But the center of focus will be clear, yet apt to depict a different scene at reasonably spaced time intervals. Many of those who contributed their input to this current issue are educators who participated in a special report of *Sea Technology* (June 1987) devoted to ocean engineering. The ten-year lapse between that special report and Schwalbe's article certainly represents such a reasonably spaced interval, from which discernible changes in the basic complexion of ocean engineering are evident. Most of these can be oversimplified as having been technology-driven changes. The advent of powerful yet small and affordable computers has enabled seemingly limitless possibilities of "smart" subsea work systems, vehicles, sensing, processing, and communication systems, all of which were the focus of much of the 1987 document. Perhaps the events contributing most to the changes now afoot, resulting from the five years since that special report on ocean engineering, have been more political than technological. Recent and pending world events portend to have as much to do with shaping both *how* best to train ocean engineers, as they do *how many* will be needed.

## HOW?

If ocean engineering is a discipline in a constant state of flux, so then must any curriculum intended to adequately prepare its graduates be flexible to changes aimed at keeping pace with technological and political climates. Former MTS President, Robert Abel, who chaired the U.S. delegation of the UNESCO working group on education and training in marine sciences, suggests that courses in accounting, marketing, economics, and practical government should be blended into the ocean engineering curriculum.

Indeed, a common opinion among many of those I polled was that ocean engineering programs can best prepare their students for the future by including management courses in their curricula. University of New Hampshire's professor of naval architecture, Gene Allmendinger, asserts that well into the next century, critical issues facing ocean engineers (he says he is now inclined to believe there really *is* an animal called an ocean engineer) will include management of the ocean environment, its protection, recovery of resources, and legal considerations; that universities must recognize such complex problems are solved by team rather than individual effort and formal training should take this into consideration. This, of course, speaks to the fact that human resources are among those that require sound management.

Another commodity requiring management, and subsequently skills and techniques to manage it properly, is data. Athelstan Spilhaus describes education as a four step process: (1) observation, (2) understanding, (3) prediction, and (4) control. With the plethoric availability of data being acquired each and every second by today's remote sensing techniques and ubiquitous instrumentation arrays, he fears we are frequently dithering between steps (1) and (2). Confounded with the shear volume of data and its continuous acquisition, insufficient time is being spent on evaluating what it means and how to use it. Spilhaus muses about the effect of declaring a one-year international moratorium on the additional collection of data, while the existing data base is sorted to the extent that facilitates its most thorough understanding and use. The very same technology that has enabled so many to take so much data, namely the microprocessor, has also brought to bear powerful relational data base management tools, available to and affordable by individual students. While data base management skills are essential to the core knowledge of students preparing to enter today's business world, it is not a subject likely to be found in an ocean engineering curriculum.

Arguably, skills such as these might be of more relevance to the aspiring marine scientist than the ocean engineer. As International Submarine Engineering President Jim McFarlane notes, the personal computer has had a major impact that few, if any of us, could have imagined. However, just as with the slide rule before it, the personal computer-literate user's productivity is a function of his or her ability, through association and cognition, to use fundamental knowledge.

One topic upon which everyone seems to be in lock-step agreement is the importance of emphasizing in undergraduate programs the engineering and physics fundamentals, as well as chemistry, English, and some of the life sciences. For such a seemingly "motherhood" issue, however, there is considerable variety of opinions regarding how best to accomplish this foundation.

Some argue that ocean engineering is too high a level of specialization for an undergraduate program, while others insist the field is so broad it is ill-defined. The problem here appears to be one of a mass-flow nature. That is, just how much in the way of a solid grounding in the fundamentals, management (ocean resources, human and data base), English and other essential communication skills, in addition to critical ocean engineering subjects can be crammed into a four-year period? Norm Caplan, director of the National Science Foundation's Ocean Systems Engineering Program, observes that undergraduate programs can be tailored to prepare the student for either graduate studies or for work as an engineer. In the perhaps infrequent cases where a student has decided early in his undergraduate career both to specialize in ocean engineering and to pursue an advanced degree, there would seem to be some advantages in obtaining a baccalaureate degree in one of the more traditional disciplines. Definitely there is a need (demand) for a supply of highly skilled undergraduate level engineers who are well versed in the additional challenges that working in, on, and under the sea present. As founder of Florida Atlantic University's undergraduate program in ocean engineering, Captain Charles Stephan freely admits his opinions may not be totally unbiased. But Dr. Stephan believes the professional success of that program's 1,000 plus graduates over the past nearly twenty-seven years speaks for itself.

Even many of those who felt that ocean engineering is a specialty best built at the graduate level upon a strong undergraduate foundation in more traditional engineering agreed that there still exists a need for a limited number of high caliber undergraduate programs. Jack Flipse of Texas A&M (which has both undergraduate and graduate programs in ocean engineering) believes, however, that no additional undergraduate programs are necessary to meet this demand. Professor Flipse, who is also founding director of the Offshore Technology Research Center, makes an observation that might not be entirely obvious to all undergraduates considering whether to pursue an undergraduate degree in ocean engineering. When ocean-related jobs are scarce, it is more difficult for the ocean engineer to market himself in one of the traditional disciplines. One could imagine that a recent graduate of mechanical engineering would face less of a daunting challenge seeking work in a shipyard than would a graduate with a degree in ocean engineering looking for work, for example, designing farm machinery.

Regardless of how many courses in management and economics the student manages to undertake along with his engineering studies, he is still at the mercy of whatever job market and economic climate awaits him upon completion of his academic tenure. While it is incumbent upon the student to choose a course of study with which he can ultimately abide, there is also room for shared responsibility. The cognizant federal agencies, universities, and individual engineering departments should see to it that students are not only properly trained, but also are guided to programs in a manner that will help ensure, to the extent this is possible, that proper numbers are trained.

## HOW MANY?

A much heralded dilemma in the education arena is the projected shortfall of engineers and scientists our country faces as we approach the year 2000. I have always had considerable difficulty reconciling this projection with the steady stream of letters and resumes I receive from outstanding engineering graduates still seeking that crucial first job, scores of experienced but laid-off engineers, and more recently those in defense-related activities who have begun to recognize writing on walls. Nonetheless, I, with many of my colleagues, have accepted this imminent shortage as a looming disaster, for which all must rally. Along with having the prerogative to omit altogether from this issue representation of some of the country's preeminent institutions, as guest editor I am also afforded the privilege of writing this introduction at the last possible moment. This provides me the advantage over all the authors of access to the latest news. I cite here a front page article of the April 9, 1992, issue of the *Washington Post* with the headline "Scientist Shortfall a Myth." At the time of this writing, a congressional subcommittee is hearing testimony from a number of witnesses—including the National Science Foundation (NSF) official who made this projection—that the subject study was, at best, flawed. According to the *Post* article, under questioning by Representative Howard Wolpe (D.-Mich.), the study's author testified that he merely sought to depict "a hypothetical example and [that the study] should not be taken as a forecast of what would happen in the real world." Apparently the study and its methods met with such criticism within NSF at the time it was conducted that the agency's Office of Legislative and Public Affairs refused to approve it as an NSF document. Yet the draft document was reproduced informally and distributed widely. It is perhaps this unusual method of dissemination that helps account for how this maxim became so well entrenched in our lore. This projected shortage was decried in no fewer than fifty-five speeches given by former NSF Director Bloch and has thus found its way both into the unaccountable popular literature as well as refereed journals, including this one. I have been careful here to list the source of this late-breaking news in the event that the *Post* article is itself debunked subsequent to this journal going to press.

Again, germane to this issue and of perhaps comparable importance to its readers is not only *how* ocean engineers should be trained, but also *how many*. The NSF study used only a peak period of past supply as a measure of future demand. While much lip-service is given to supply and demand as being a factor in plotting the course and actions of our technical institutions, few engineers in any discipline are truly versed in such standard forecasting practices.

## WHEN?

As the authors of the first paper point out, whether or not ocean engineering should be taught at the undergraduate or graduate level is not the most pressing question facing the ocean engineering community. And I submit that the correct answer to the question posed earlier—just how much vital knowledge can be crammed into an undergraduate program—is simply, *not enough*. The same answer applies to master's and doctorate programs. The findings of the ECOR Working Group on Ocean Engineering Education described in the Canadian article herein confirm the importance of ongoing education and training accessible to ocean engineers in the work force. In the United States, one vehicle that has proved particularly successful at keeping the practicing ocean engineer up to speed with the most recent methods and techniques, or simply enabling him to expand his base of knowledge, has been the tutorials offered in conjunction with Marine Technology Society conferences.

It would seem the answer to the question of when to educate ocean engineers is *now—and always*. In this sense, ocean engineering is no different than any other discipline—traditional or otherwise. Education is a life-long commitment.