IN THE OCEANOGRAPHY CLASSROOM

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WHY IS IT SO HARD TO REFORM OCEAN SCIENCES EDUCATION ?

To reform any human affair exacts great effort from the people who direct the affair. So it is with ocean sciences education. Many of the people directing it are striving to make "the change for the better" that we call "reform," because it will enable students to learn better. The nucleus consists of the K-12 teachers and college and university education instructors and ocean scientist instructors who have made the change. The K-12 teachers are being prepared in the pedagogy of reform by their education instructors. In this manner, they learn *how* to teach in support of the *National Science Education Standards* and the *Benchmarks*. But, like all other students, they must learn the science content from ocean scientist educators who, for the most part, do not know how to teach by the *Standards*. As a result, the teachers are not being taught ocean sciences as they are expected to teach them. Nor are other undergraduate or graduate students learning ocean sciences in the manner that assessment studies have reported to be most effective. In brief, a major impediment to the reform of ocean sciences education is the ocean scientist educator whose teaching does not support the reform. That this impediment should be the ocean scientist educator ought to surprise us. Although it doesn't, here's why it should.

The historian of science Alexander Vucinich, in his book *Science in Russian Culture: A History to 1860*, notes that: "Every scientist is an agent of cultural change. He may not be a champion of change; he may even resist it, as scholars of the past resisted the new truths of historical geology, biological evolution, unitary chemistry, and non-Euclidean geometry. But to the extent that he is a true professional, the scientist is inescapably an agent of change." Deep inside us we know this to be true, for change for the better—better understanding, in the case of our research—was inculcated into our minds as graduate students and has persisted as a value ever since. It is remarked on by the late Nobel immunologist Sir Peter Medawar in his classic *Advice to a Young Scientist:* "...a scientist does not hold exactly the same opinions about his research from one day to the next, for reading, reflection, and discussions with colleagues causes a change of emphasis here and there and possibly even a radical reappraisal of his way of thinking." And so, change for the better—that is, reform—comes as second nature to ocean scientists. Why, then, do so many resist the reform of ocean sciences education? I think the answer has two parts.

The first part is found in the answer to a question formulated imaginatively by the science-and-technology scholar Franklin A. Long: "What are scientists for?" He answers: "And clearly it is not adequate just to say that they are to produce science. Most scientists have always been something more than purely scientists. Some scientists are also educators; others are partly managers; and still others are partly industrial or governmental technicians.... The number of scientists devoted solely to the production of basic research has always been small and will almost surely always remain small." It is as researchers that we relish change and reform, but beyond graduate school only a few of us remain solely basic researchers, or purely scientists.

Most scientists assume additional responsibilities. Those who will succeed as partly managers must prepare themselves to manage. In academia, candidates for positions as department chairs and college deans are now attending workshops or being assigned to mentors for training. Once appointed, they must change their department or college in accord with the economic, demographic, political, and other social pressures exerted on the university. Scientists in industry must prepare to fit in with the vision of the company and change as the company deals with economic and other external forces. Government scientists must prepare for political realities and be able to change science programs so as to align them with ever-changing national purposes. Even such sketchy examples as these demonstrate that scientists are indeed adept at preparing themselves to be successfully "something more than purely scientists" and at making changes

within these roles—except, that is, for the role of "educator."

Most ocean scientist educators do not prepare to be educators and they resist the reform of science education. I believe this omission and resistance are not in defense of research time, for scientists accept positions as partly managers, industry scientists, or government scientists and tolerate less time for basic research. Nor is it due to a lack of reward for teaching, though there's little. No, the lack of preparation for education and the resistance to educational change seem to arise logically because scientists approach the role of educator in possession of a fully developed paradigm of education, that is to say, a fully developed frame of reference that allows them to make sense out of how they educate students. They see no reason to change.

Ironically, this paradigm, which they have accepted tacitly through experience as student and faculty member, has become so internalized that they are oblivious of its existence. It has been referred to as "deeply ingrained in each of us," as being as "invisible" as "the context in which [we] live," and as seeming to be "a force of nature." It is called the Teaching-Centered Paradigm. Although discussions of the paradigm are normally confined to its lecture teaching method and its passive classroom environment, the paradigm, "invisible" though it is to the educator, determines the educator's educational assumptions, goals, and assessment of results. It also determines the educator's sense of educational responsibilities, relationship with students, and motivational and mentoring responsibilities. The following outline of the paradigm should indeed feel "deeply ingrained in each of us."

The principal educational assumption of the paradigm is that subject matter content is sufficient. The principal goal is for the educator to transfer information and for students to accumulate knowledge. Assessment usually aims to determine whether this information still resides in the students' minds. The principal responsibility of the educator is to possess science content knowledge. It follows from this that anyone who knows the science content is capable of teaching it. Learning how to teach is a waste of time over a routine activity. The educator's relationship with students can be impersonal, because it is the educator's job only to provide the information. It is the students' job to learn it. Today's students differ little from the educator as student. Students are expected to be self-motivating. Mentoring is helping the student with science content.

The paradigm of reform in science education is quite different. It is the Learning-Centered Paradigm. The principal educational assumption of this paradigm is that the process of forming knowledge—that is, of learning—is just as important as the content learned. The principal goal is for the educator to create a learning environment in which students can discover how to restructure the new information and their prior knowledge into new knowledge about the science content and practice using it. The students' learning is assessed often in the classroom in order to change the teaching immediately so as to enhance learning. Classroom teaching methods are mainly active learning methods rather than lecturing. The principal responsibility of the educator is to possess *both* science content knowledge *and* the knowledge of how to present the science content so that the particular students in the class, who are today very different from the educator as student, can learn it most effectively. Teaching is a complex skill that is learned well through training. The educator's relationship with students is a partnership of learning. The educator motivates students by helping them learn how to learn and mentors them for lifelong learning.

I believe that the fundamental difference between these paradigms is the extent to which they require educators to reflect critically on their teaching. The Learning-Centered educator's teaching cannot exist without critical reflection, because the process of student learning is as important as the science content learned. The question "How do I help my students learn better?" abides with this educator. By contrast, the Teaching-Centered educator has little need to reflect deeper on teaching than "What topics do I cover, what problem sets to use, which questions to put on the tests?". It is ironic that "reflection," an ability that, as noted in Medawar's quotation, is used by scientists to change their opinions and ways of thinking about their research, is not used here to change their ways of thinking about their teaching. They stand true to their paradigm, which doesn't require it. And the paradigm invests them "invisibly" with the self-assurance of "a [presupposed] force of nature." Why challenge such a "force"? A few ocean scientist educators know why: because it is not a force. It is an experiment. They teach with the Learning-Centered Paradigm, a better experiment. Join them in the reform.

(The two paradigms are contrasted in my paper "in press" in the *Journal of Geoscience Education.*)