Teaching Environmental Sciences in an Evolving World

BY MATTHIAS TOMCZAK

AFTER SEVERAL DECADES of research and two decades of teaching, I have now come to a point in my career that makes for a decisive change: I reached retirement age. While this does not mean that I have to drop all my tools and leave the research community, it marks the end of my involvement in university teaching. This education column will therefore be my last contribution to *Oceanography* on aspects of marine science teaching. It draws not on personal experiences in the classroom, but rather offers a few reflections on the rapidly changing situation of our science, and what the changes imply for those of us who work in education.

A constant challenge for the teacher of any environmental science is the need to demonstrate the different character of laboratory science and field science. Much can be achieved through carefully designed laboratory experiments, and most principles of physics, chemistry, and biology are best explained and demonstrated in a laboratory setting. But the essence of environmental science is the collection and interpretation of data from field situations over which the observer has very limited control. This poses specific challenges, which students should learn to appreciate and understand so that they can judge the reliability of observations with regard to data quality and data density in space and time.

The large amount of information produced by new generations of oceanographic instruments makes it additionally important to teach our students what is involved in the production of databases and environmental time series. I recently visited the French Argo centre in Toulouse and had an interesting discussion about the best way to calibrate the salinity records of Argo floats. Not too long ago it was impossible to obtain reliable salinity data from moored instruments or from drifters such as the Argo floats, which report their observations for periods of years without the possibility of regular sensor calibrations. Modern salinity sensors achieve extraordinary sensor stability through a combination of electronic, mechanical, and chemical methods (worthy of detailed explanation to the students!), but they still produce erroneous data on occasion as a result of sensor drift, biological fouling, and other effects.

Validating Argo data involves comparison with historical observations. This is usually done by calculating the average and standard deviation of all observations within a given radius around the float and checking whether the float observations come close to the historical data range. The Southern Ocean is characterized by several frontal systems, and a float in that region of the world ocean is usually located either on one side of a front or the other. Using historical data within a fixed radius around the float often includes data from both sides of the front and produces an artificial

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historical average that is not representative of any oceanographic situation and cannot be matched by the float observations. As a result, the observations may be classed as doubtful. My colleagues in Toulouse showed me how a data validation procedure that compares the float records only with historical data from the same side of the front is more appropriate to the oceanographic situation and increases the acceptance rate for float data considerably.

Similar situations can be expected in the equatorial current system with its large east-west and small north-south correlation scales. I believe that environmental science education is incomplete if it does not give insight into the processes of data treatment that go into the production of the various climate databases that can now so easily be downloaded from the Web. This requires a good understanding of the regional dynamics of the ocean and its ecosystems, sufficient insight into the technology used during data collection, and a basic understanding of the mathematical-statistical methods used in data validation.

Combining one's own field observations with a regional database will allow first-hand experience with the comparison and validation of observations and should be an integral part of marine science education. The examples from Argo may be biased by my interest in large-scale oceanography of the deep ocean, but the conclusions apply equally well to the marine sciences of the coastal ocean. The number of ocean-observing systems for the coastal ocean is increasing rapidly. Easier access to the coastal zone means that most students gain their field experience there. They should be able to understand how data available for their own regions are collected, validated, and processed before they become available to the public.

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Access to the ocean is, of course, very desirable for a marine science class, but it is not an absolute requirement. What is essential is exposure to data collection in the field. Observations of capillary and gravity waves on a small lake are possible nearly everywhere. Meteorology is always a good substitute for physical oceanography, and my biological colleagues, who do not tire of pointing out the connections between marine biology and the biology of plants and animals of the solid earth, should not find it difficult to devise field observations that relate to their own field of research in situations where the ocean is not reached easily.

Being able to travel extensively in retirement also allowed me to participate in a conference on the use of technology in education. This is a field in rapid development, and many of the more than 200 presentations were variations of the same theme: how to cope with increasing student numbers by replacing components of face-to-face university instruction with Web presentations and computer laboratories. It included such elementary "progress" as shifting the cost and the trouble of printing class texts to the students by handing them out on CD, or giving lengthy text explanations of difficult scientific principles on Web pages rather than book pages without even considering the use of animation.

Such inappropriate use of computer technology will hopefully disappear as the technology develops further and teachers become more experienced with its use. But there were also some presentations that showed new possibilities of relevance to field-based sciences. A particular presentation that impressed me demonstrated the use of bicycles for the study of Newtonian mechanics. The specially equipped bikes had sensors to measure the various forces and transmitted the data to the observer in real time; they turned any bike track in the field into a well-equipped laboratory.

Newtonian mechanics can, of course, be studied and taught just as well in a classical lab, and the use of bicycles on exercise tracks was motivated more by the wish to overcome student apathy and exploit the natural interest of young

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males in physical exercise than by the advantages of innovative teaching methodology. But the idea of using technology to bring conditions in the field closer to a laboratory setting has great potential for the environmental sciences, and we might hope to see ideas in that direction in future contributions to *Oceanography*.

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Another theme that reappeared through the conference was the need for translations of scientific material, particularly for teaching and reference purposes. This is not a new requirement, but current moves in several countries in Asia and South America to strengthen their university systems and train more of their students at home rather than abroad has given this new urgency. Technology has opened new opportunities in this regard. It is often said that the Internet leads to the domination of the North American view of the world and to the demise of other cultures and traditions. Whether this will be the inevitable result depends to a large degree on the communities in the rest of the world.

The Internet offers great opportunities for collaboration across borders. The science community has a long tradition of giving free access to information (and it has to be said that North American oceanographers have been and still are particularly strong defenders of this principle, which allows scientists of other nations to benefit from the vast observation network maintained by the United States). Recent years have seen the emergence of groups of science translators who volunteer to bring important scientific texts to countries where English is not the first language of instruction. The examples shown at the conference spanned the history of mathematics, principles of physics and chemistry, and other science texts. They were produced under strict quality control and satisfy all intellectual property safeguards. Unfortunately, they did not include texts with marine science content. The international character of the marine science community should provide good conditions to establish a system of text translations, maintained by volunteers, in our areas of science as well.

This brings me to the end of my last education column for *Oceanography*. I enjoyed the privilege and challenge and appreciated the email responses from colleagues who shared my struggles to solve problems of an ever-changing teaching environment. Ongoing interest in and support for the teaching of science is one of The Oceanography Society's best features and distinguishes it from other scientific societies. I take leave now from active involvement in teaching but look forward to seeing the experiences and successes of our science teachers documented and discussed in future issues of our magazine.

Thank You and Welcome...

In this education column, **Matthias Tomczak** announces his retirement from Flinders University, South Australia, and from writing regularly for *Oceanography*. Twice each year, Matthias shared his own hands-on experiences preparing undergraduates for careers in oceanography. I want to thank him, on behalf of *Oceanography*'s readership, for his many years of contributing insightful columns to the magazine. Although we will no longer have Matthias's observations to look forward to, we are pleased to welcome **Simon Boxall** of the National Oceanography Centre, Southampton, UK, as our new education columnist. His column will debut in the December 2007 issue of the magazine.

Ellen Kappel
Editor, *Oceanography*