Geoscience education in the secondary school

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According to an article in the May 2008 issue of *Geotimes*, students taking Earth science classes in high school in the United States peaked at 28% in the 1970s compared with only 8% today. Why are there so few students taking Earth science? Of the approximately 8.25 million students attending a four-year college program in the United States, almost 20 000 are geoscience majors. This compares favorably with the 19 000 physics majors but is far below the 44 000 chemistry majors. Why are so few students majoring in geoscience with the starting salaries currently offered to graduates?

In 2006, Chesapeake Energy endowed a chair in geoscience at the Oklahoma School of Science and Mathematics (OSSM), a high school for the best students in Oklahoma. This is certainly the first endowed geoscience chair, and probably the first in any subject, at the high school level in the USA. The sole purpose of this endowment was to introduce a rigorous geoscience program at the high school level to persuade bright young students to pursue a career in geosciences. Why was this even necessary?

The answer to these questions can be found in the following areas:

- inadequate or poorly executed curriculum,
- the lack of resources and training for teachers,
- the perceived irrelevance of the geosciences, and
- public perception of the geosciences and industry.

An understanding of Earth science is recommended by the national science curriculum standards and various state standards. However geoscience education at the high school level in most states is inadequate at best, and, in many cases, downright scandalous. (It should be noted that several states have very good Earth science curricula; they are the exception rather than the rule.)

There are many reasons for widespread disregard for the geosciences. And, although this discussion will focus on the United States, I suspect that many of these issues are relevant throughout the world. The first challenge is the available curriculum. Let me start with a short example.

In his tenth grade year a young man took an AP (advanced placement) chemistry course and loved it. Eight years later, as a direct result of that course, he is working on a PhD in chemistry. Although I am very familiar with this story (the young man is my son), it could be repeated in many schools and for many topics. But not for geoscience (at least not in the USA). In my son's case, it was the advanced nature of the class and the enthusiasm and knowledge of the teacher that opened his eyes to chemistry.

Geoscience education often suffers from its status in many school systems as a "secondary" science. Biology, chemistry, and physics (often in that order) are usually required; geoscience usually is not. Where it is offered, it is usually called Earth science and often includes ecology, weather, and other topics not part of a traditional geoscience course. It is often considered a "soft" science (e.g. "rocks for jocks"), a course to fulfill the science requirement for graduation without having to take the "hard" sciences of biology, chemistry, and physics. And, there are no AP courses in geoscience to attract those

Figure 1. *A Chesapeake Energy geophysicist explains 3D seismic acquisition to students from the Oklahoma School of Science and Mathematics.*

Figure 2. *Students from the OSSM Exploration Geoscience course in the field learning first hand about 3D seismic acquisition. The reflective vests, glasses, and hard hats were required safety items in the field. The students were delighted to know they got to keep them.*

truly interested in science. (There is an AP environmental science course that covers many geoscience topics, but it is primarily focused on environmental issues and pollution case studies. It is designed to give students without the mathematics background for the "hard" sciences an advanced science course.)

(Note: For those unfamiliar with the U.S. educational system, AP courses are college-level courses taught in high school to allow students to get a head start in college. A student who passes an AP test with a sufficiently high score is often excused from taking that course in college and sometimes given credit for that course.)

Although there are good curricula (text books and teaching methodologies) available, many high school Earth science teachers are inadequately trained in the geosciences. Although at first glance this may be understandable when teachers are seldom paid close to what they might earn in industry, this pay disparity seems to be largely irrelevant—most teachers choose to teach rather than work in industry. A more likely cause is that most Earth science teachers must teach other sciences as well and do not have Earth science or geology degrees.

One of the results of this lack of teacher training is an inconsistent presentation of material. Some schools include a fair amount of the traditional geosciences (rocks and minerals, fossils, stratigraphy, structure, etc.). Others concentrate on a broader, environmentally based curriculum. Where assessments are used, most courses are based on what is on the test.

There are a number of efforts to improve the geoscience literacy of science teachers. Many states have summer workshops for teachers to improve their geoscience knowledge and learn methods and resources for presenting geosciences in the classroom. These efforts are generally funded at the state or local level. For example, in my home state of Oklahoma, we have the Oklahoma Energy Resource Board (OERB), a partnership of all state oil and gas producers, which presents workshops for teachers and supports them throughout the year by recruiting and training volunteers to visit the classroom. For several years my own school, OSSM, has received a grant from ConocoPhillips to present a one-week science workshop that included geosciences for the first time this year. Other workshops are funded by the National Science Foundation or other government programs.

The geosciences are often perceived to lack relevance in our modern world. Physics (and its application, engineering) brings us our tools and toys. Chemistry is responsible for medicines and household products. Biology is relevant for health care, nutrition, and all our living. They are useful precursors for college and essential general education for those who do not attend college. However, in spite of the many political, economic (e.g. the price of oil), and safety issues associated with living on planet Earth, the public sees little relevance to Earth science.

Recently, 30 scientific societies commissioned a survey of 1000 likely voters in the USA. Of these, 63% selected developing new medicines and curing diseases as an important contribution of science to society. Only 32% considered identifying the best ways to protect our environment and natural resources as important; this was the only geologically related answer in the top five. (The fifth on this list received only a 21% "important" rating.)

A more insidious form of this is the current debate in several states over creationism, intelligent design, and evolution. Although this may not be a major concern throughout the world, the school boards in several states have eliminated their Earth science requirement rather than deal with this issue. In the same survey cited above, 38% favored teaching religion in public school science classes. (Interestingly, 79% knew about plate tectonics, but only 53% knew that dinosaurs and humans did not live at the same time.)

Because the geosciences seem to lack relevance, there is little support from the community to teach either Earth science or a rigorous geoscience curriculum. The general lack of interest in science and mathematics among the populace provides little incentive for school boards to push geoscience education in most states.

In an effort to evaluate the effectiveness of the educational system and the quality of high school graduates, most states

have developed tests based on curriculum standards. One effect of these tests is that teachers spend most of their time on subjects they cover and little time on subjects not covered by the tests. With little emphasis on Earth science in most tests (regardless of the official standards), little time is devoted to Earth science.

The picture is not all bleak, however. Several states have very good Earth science programs. Generally, these states have standards (and tests for those standards) that require Earth science. For example, every high school student in New York must pass a pregraduation test in Earth science. Several local school systems in other states have reached agreements with local or regional colleges and universities to give college credit for high school Earth science courses, bypassing the formal AP process.

Perhaps the biggest single obstacle to recruiting students into geoscience programs is the public's perception of the industries that use geoscientists. A large proportion of the USA "knows" that "big oil" is interested only in money and cares nothing about the environment or people. (This is further "proven" by the high price of oil, over US$120 a barrel as I write this.) In this view geoscientists, as explorers for natural resources, collude in this distain for the environment.

The public perception of mining companies and mining geoscientists is worse than that of petroleum geoscientists. However, their products are not as uniquely visible as oil. Gasoline prices can be seen on almost every street corner and deeply felt in the pocket book about once a week.

The cyclical nature of employment in the natural resources industries has not helped. Although all industries are cyclical, and no jobs are truly secure, the public hears about layoffs in the oil and/or mining industries and decides that a career in another field is better.

An understanding of the problems is only the first part of the equation. The real issue is what to do about it: What is the solution? What can we as an association, as geoscientists, and as citizens do to increase the basic instruction in geosciences and recruit more students into the field to fill the job vacancies that will only increase with the retirement of the baby boomers?

The first step is to support our Earth science teachers. If our teachers are knowledgeable about their subject and excited about teaching it, students will take their courses. We must sponsor workshops for teachers, such as the ConocoPhillips workshop at the Oklahoma School for Science and Mathematics. Individually, we must be resources for these teachers, offering to present our science to their classes. We can do this through our local societies and through organizations like the Oklahoma Energy Resources Board, which trains professionals for school presentations.

Individual companies must sponsor geoscience education. Although endowing a chair at a rigorous science and mathematics high school as Chesapeake Energy Corporation did at OSSM is good, there are other ways to support teachers and students. My Exploration Geoscience class at OSSM made two field trips this semester. Our first trip was to the Chesapeake campus in Oklahoma City where we were treated to an explanation of the exploration process and a walk-through of a 3D project (Figure 1). The students especially enjoyed the 3D visualization of the subsurface in the visualization room.

Several weeks later, the class spent an entire Saturday in the field, hosted by Chesapeake and Dawson Geophysical Company. They were impressed with the scale of the operation, amazed at the area covered, the amount of equipment used, and the efficiency of the operation (Figure 2). The students were given the opportunity to sit in the vibrator trucks. As one student said, "We even got to push the button to start the vibrator!" When the trip took longer than originally planned and the students were late for a function back at the dorm, there was not a single complaint.

As citizens we must be advocates for Earth science in the curriculum, for Earth science teachers, and for the students who take these courses. We must talk with our neighbors and business contacts about the importance of geoscience in our world today. We can use issues such as global warming (an extremely hot topic), natural disasters, energy prices, and a host of other opportunities for dispassionate, scientific discussion. Most of our immediate families know the importance of the geosciences. How many of our extended families understand this importance?

We need to multiply our effort by actively supporting online and local outreach efforts such as the SEG Virtual Geoscience Center. The next generation in most of the world is intimately connected to the Internet. They can be reached by good online resources. Volunteer to build an online story or game for children or youth. Develop an easy geoscience demonstration for teachers. Write about the successes and how they were achieved—they can be a template for other teachers.

This discussion has, of necessity, been primarily about the United States. Although the problems encountered around the world may not be identical, I suspect that they are similar. I would be very interested in starting a discussion about worldwide and local efforts at high school geoscience education, successes, problems, and the solutions to these problems. As an international society, SEG has the resources (the people) to solve these problems. It is up to us as geoscientists to develop adequate geoscience education in our secondary schools. No one cares about our field as we do. No one knows about our field like we do. TLE

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