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Is There a Future for Science in a Scientific World?

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A quick survey of local newspapers over a two-day period recently revealed five articles based on scientific advances or problems. Although such items could be read by average readers, they would certainly appeal more to those with a healthy interest in science and they surely would be better understood by those with current formal course work in science. The articles involved such concepts and terminology as "DNA, polymerase chain reaction, AIDS, alpha interferon, tumor necrosis factor, gene therapy, white blood cells, artificial insemination, fertilization clinics, weightlessness, basic research, microgravity, oncology, colon carcinoma, and cancer genetics." Readers may be scared off by terms such as these and just stop reading. The vocabulary may even remind them of their old science textbooks. It has been estimated that there are more new words in a high school science textbook than a student learns in two years of a foreign language.

An atmosphere that is so heavily committed to and controlled by scientific activities demands that citizens, as well as their leaders, possess a healthy skepticism about scientific (and especially un-scientific) discoveries and pronouncements. It is important that observers, as well as practitioners, be aware of the scientific method of analysis. A foundation knowledge in a number of different disciplines is important, along with at least a limited vocabulary of commonly used terms.

Critical thinking, problem-solving, evaluation skills — these are the skills the layperson needs to participate knowledgeably in a rapidly changing world. There is probably some merit to the old idea that formal courses in the sciences may provide mental exercises to sharpen a student's thinking ability. The traditional goal of providing exposure to a spectrum of recognized fields of study is also likely to carry some importance for a "complete" education. However, the real merit to studies in the sciences may lie in a more practical arena.

Our society is so strongly based in modern scientific advances that anyone who wishes to understand the many processes that have a direct effect on an individual's life must have the ability to read and understand rudimentary scientific presentations. To form opinions on scientific advances and their utilization, not to mention making judgments about expenditures of tax money for scientific studies, each educated citizen must possess some ability to interpret the phenomena in question.

A plethora of recent reports and studies have decried the dismal level of scientific knowledge of today's students. By the third grade, half of all U.S. students don't want to take science anymore. By the eighth grade, 80% dislike science.

One report (National Assessment of Educational Progress) found that only 7% of 17-year-olds have the science skills necessary to perform well in college-level science classes. A report by the International Association for the Evaluation of Educational Achievement found that in a field of 13 countries, U.S. high school seniors having two years of physics ranked 9th, seniors in advanced chemistry ranked 11th, and in biology, the most popular science course in the United States, our students ranked last.

Is it any surprise then that only about 15% of American adults know that the Earth orbits the Sun in one year, or that 43% know that electrons are smaller than atoms, or that 37% know that dinosaurs lived before the earliest human beings? Is it surprising that astrology dictated the schedule of a president of the United States?

For the many reports identifying this "scientific illiteracy," there are as many that propose to explain the causes of the education deficit.

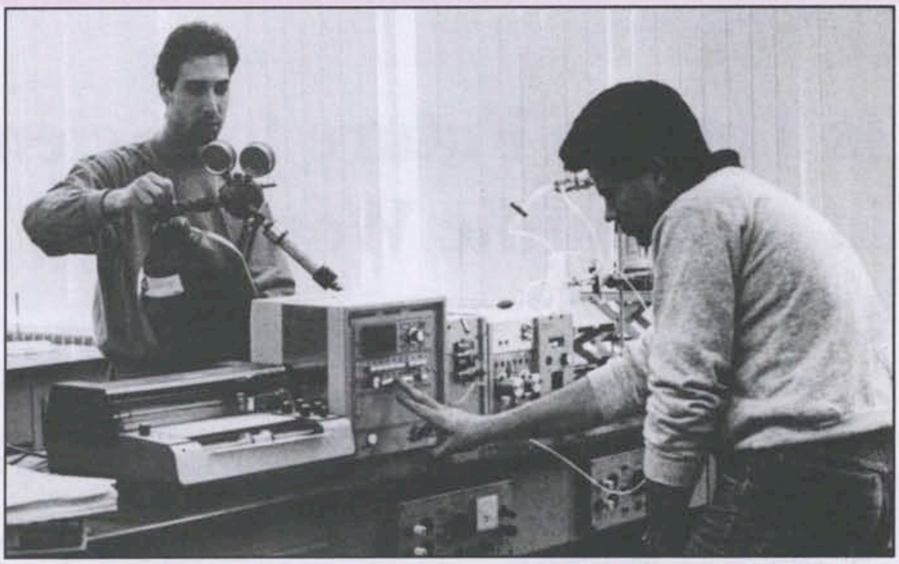
In a speech delivered before the Council of Scientific Society Presidents, former Secretary of Education Lauro Cavazos listed five reasons for the lack of a solid foundation of science knowledge among students. For one thing, schools at all levels devote too little time to science. A second reason is that science presented in a science curriculum is fragmented and specialized rather than interdisciplinary. Third, the methods of instruction include too little "hands-on learning." Fourth, textbooks don't use relevant or applicable problems and examples. Finally, teachers aren't appropriately prepared or qualified. Elementary teachers take too few science courses while in college and one out of two high school teachers is assigned at least one class outside his or her degree area.

More and more, educators and scientists alike are calling for a science curriculum that emphasizes the process or methodology of science rather than description and terminology. "Science education should emphasize ideas and thinking at the expense of specialized vocabulary and memorized procedures," affirms a 1989 report by "Project 2061," the American Association for the Advancement of Science's taskforce charged with designing models for a national science curriculum.

So far Project 2061 has produced a survey of the needs of science education for the future without a new curriculum. The new curriculum is on the way, but the preparation is purposefully slow. The National Science Teachers Association has also mounted a massive attempt to produce a new curriculum that has already been tested in California. Their program is called "Scope, Sequence, and Coordination" and has received $8.6 million for implementation at five other centers.

Of course, there is a core bit of science — basic principles and laws — that students should learn and understand, but memorized facts can change. A first grader can tell his mother that Pluto is now closer to the sun than Neptune, even though she learned differently in college just ten years ago. Facts, scientific concepts, and the resulting technology can change rapidly.

The Department of Commerce has identified "emerging technologies" which are projected to have a total economic activity of about one trillion dollars by the year 2000. These technological frontiers include advanced materials, superconductors, advanced semiconductor devices, digital imaging technology, high-density data storage, high performance computing, optoelectronics, artificial intelligence, flexible computer-integrated manufacturing, sensor technology, biotechnology, and medical devices and diagnostics.



Chemical warfare, amniocentesis, CAT scans, recycling efforts, Patriot missiles, FAX machines, pesticides on lawns, food additives, AIDS transmission, waste management — these are all issues that graduates of the seventies have had to face in the more than a decade since their last science class at Bridgewater State. Did their science classes in the sixties and seventies prepare them at a personal level to cope with these everyday contacts with science? Are these former students equipped with the knowledge and skills to consider, evaluate, and perhaps vote intelligently on issues regarding the environment, information processing, energy, space, drugs, defense systems, biotechnology? Did they receive the kind of education that insures understanding and thus support for technical progress? Were they prepared to be scientifically literate managers? And what about all of those currently in the education system? Are they being prepared adequately?

At the college level, critics have decried reductions in required science courses for liberal arts majors and a lowering of rigor in the remaining science classes. In spite of the tradition of strong science exposure in teacher preparation at Bridgewater, this college has followed the contemporary demise of science courses in the curriculum for elementary teachers. Older graduates are often astonished to learn that only two science courses are required and taken by our future elementary teachers, in contrast to the five courses representing biology, physical sciences and earth sciences, plus mathematics, that they took in the sixties.

Some of our graduates from the past who are now seasoned teachers are incredulous when they are told that the change occurred with the advent of a new set of general course requirements. With the installation of the requirement for two science courses in different disciplines (only one being a lab course), Elementary Education majors began to follow the same science course exposure as other non-science curricula.

If new teacher certification regulations are implemented for the Commonwealth, future teachers will be required to obtain a bachelor's degree in a traditional liberal arts or sciences discipline. It is possible that such students will obtain degrees in science curricula that have barely one or two science courses more than the 1960s teachers had. These courses will be concentrated in a major discipline, rather than spread across several subject areas.

The wisdom of the new certification requirements seems to lie in the idea that it is blatantly ridiculous to attempt to teach students to teach subjects at any level if they do not have an in-depth exposure to the knowledge of the discipline.

An old axiom of educational technique states that "we teach as we were taught." Thus, it is difficult to see major changes in the material presented in scientific disciplines without major efforts to revise courses and curricula. Max Planck, a well-known physicist, said in his autobiography, "A new scientific truth does not triumph by convincing its opponents and making them see the light, but rather because its opponents eventually die, and a new generation grows up that is familiar with it."

In the thirties and forties, biology courses could present a survey of the whole science and demand that students commit most of it to memory. However, it is impossible to continue to present even a substantial core of biological conceptual knowledge in the 1990s. The field is overwhelming in terms of the amount of knowledge and we cannot continue to superimpose new knowledge on top of the traditional array of information for general courses.

Neither can we expect secondary schools to pick up all of the traditional subjects that must be left out, although that is clearly one way to provide broadened coverage. There is some justified concern that students will not select an adequate array of courses if left to pick their own in a college curriculum that does not specify required courses.

At Bridgewater, over the years the Biology curriculum has added new courses while dropping some traditional ones and making others optional that were formerly required. Some faculty worry that we are allowing students to leave without everything they need — and yet our course list has grown so long for future teachers that it is not reasonable to expect that a four-year stay will be long enough for a student to finish the program.

Now that curricular revision is underway at elementary and secondary levels, it is probably an inappropriate time to think about curricular revision at the college level as well.

This seems to be true for two reasons: (1) students will be coming to college with different science preparations and (2) future teachers will have to be prepared for the new techniques and approaches to science in the public schools.

Adjustments to the new world of science will be difficult for a traditional college like Bridgewater, but there can be little doubt that adjustments will be made during the next ten years. If a pattern is followed that can be predicted for the rest of the world, it is likely that greater changes in course and curricular structure will occur than we have seen in the last thirty years.

Science majors will be exposed to in-depth studies in concentrated areas, without an attempt to provide a broad survey of the field. While this seems to counter the need for preparation as an educated person who is adaptable to a number of different areas, it is not anathema to that goal. The fundamental techniques of the field will be learned and scientific principles will be developed through pursuit of model research projects. Solid, hands-on learning will be involved, while reading of current literature in the field will be required in an atmosphere of critical thinking and problem solving.

If the best approach possible is developed, each student will work closely with faculty each year in an interdisciplinary program that not only correlates studies in easily allied fields, but in more difficultly contrived patterns as well. With careful planning, biology courses can be integrated with arts, social sciences, and humanities. Weekly seminars with all four or five of a student's instructors could provide a true interdisciplinary experience and assessment of progress.

Non-science majors will also need more exposure to science, including in-depth studies along with a general approach to methods of study in science and the significance of such studies. Here, as with science majors, a coordinated and well-planned interdisciplinary effort will be essential for future graduates.

Maybe there will be no effort made to look forward to these changes, but if there is not, we are likely to find that the fears of the nation in regard to the demise of science are justified.

Bridgewater was well ahead of its time when Louis Carmel Stearns introduced our first science course (Gardening I) into the Normal School curriculum in 1908. Over the years the reputation of strong science has been a part of the Bridgewater tradition. It is difficult to imagine that this tradition will not continue during the years to come.

If the past is a good predictor of the future, there will be significant changes in science education as the nation strives to maintain a position of educational excellence in a changing world.❧