Statement on New Mexico Science Education
and the 2003 Revisions to New Mexico Science Standards

by the Los Alamos National Laboratory Fellows [1]

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Summary

Many workers in New Mexico's national laboratories, industries, and academic research institutions need a strong foundation in science. Furthermore, understanding of science and technology is a necessary part of active participation in our increasingly complex, technology-based society. Public-school science education is critical for supporting these needs. The Fellows of Los Alamos National Laboratory have examined the proposed 2003 revisions to the New Mexico Science Standards[2] and find them well suited to these goals and admirably representative of current scientific practice and thinking.

I. The importance of science education in New Mexico

The strength of Los Alamos National Laboratory (LANL) is inextricably linked to the quality of public education in New Mexico, and in particular to the quality of science education in New Mexico.

LANL employees work at one of the most science- and technology-intensive institutions in the country. Some 57% of LANL employees have a post-secondary degree in science or engineering, and 31% of these degreed employees received such a degree in New Mexico.[3] This important pipeline is fed by New Mexico's public elementary, middle, and high schools. Only 6% of LANL science/engineering PhDs were granted at New Mexico universities, but 63% of LANL Associate degrees were granted in New Mexico.[3] Scientific and technical knowledge is vital throughout the complex LANL work environment, and is important even in jobs that do not require post-secondary degrees or that have little apparent science and technology content (e.g., business administrators, firefighters, lawyers, public-relations spokespersons).

In New Mexico, LANL is not alone in its reliance on technically literate people—our entire state relies heavily on science and technology. In addition to its two large national laboratories and the many other federal facilities, including White Sands Missile Range, the Air Force Research Laboratory, and the Waste Isolation Pilot Plant, New Mexico has many tech-based private employers. These include contractors to the federal government as well as traditional technology-based industries such as mining, oil, and gas, and modern technology-based industries such as electronics.

II. Science and technology as the new century begins

Scientific knowledge, its application in technology, and its relevance to society have advanced dramatically in the past several decades, and the pace of that advance shows no signs of slowing down.

Scientific advances have created new unity among what were historically considered as separate "sciences." Advances in nuclear and subatomic-particle physics and in techniques of astronomical observation have led to an understanding of the formation, evolution, and death of stars. Recently, these advances have yielded an accurate measurement of the time elapsed since the Big Bang and the first observations of planets orbiting stars other than our sun. Thus, astronomy and physics have merged, strongly uniting man's understanding of the Earth and the rest of the universe. Advances in chemistry and biology have led to an understanding of the molecular basis of heredity and of other biological processes, uniting chemistry and biology in ways that confirm and augment earlier understanding of the evolution of life. In this area, science is now developing a knowledge of biomolecular dynamics and how networks of biomolecules work together to accomplish their tasks. Biochemists have even begun to investigate the genomes of organisms near the roots of the tree of life billions of years ago, before multicellular organisms appeared. Radiochemistry, paleontology, and geology have become interdependent and united. Condensed-matter physics, metallurgy, and inorganic chemistry have cross-bred to produce materials science. In all areas of science, increasingly complex systems are coming under investigation and are being understood.

In parallel with such fundamental scientific advances, an unprecedented interdependence among science, technology, and society has arisen. Few can imagine living without modern electronics. Application of molecular biology to the study of infectious disease has contributed to diagnostics and to drug and vaccine design, with a great benefit to public health, through an understanding of biochemical mechanisms and the extent of pathogen diversification. Science's broader impact on medicine is vast, revolutionizing diagnostic equipment and the treatment of disease, and creating new, controversial possibilities such as cloning. Even the food we eat is affected by recent science and technology, as in genetically modified foods. National defense relies heavily on science and technology, both for traditional conflicts and for homeland security. Energy from fossil fuels, nuclear reactions, and renewable resources is transformed, transported, and used on an enormous scale, often in environmentally unsustainable ways that will require scientific resolution. Neither individuals nor society can function today without science and technology.

The explosion in the quantity of all kinds of information, the easy availability of that information, and the pace of change in relevant information that is taking place today are also dramatic. There is a profound need to sort useful information from useless information, fact from opinion, and truth from lies. Thinking skills associated with science, such as logic, informed skepticism, and the ability to make quantitative estimates, are essential in this age of information overload.

III. Science education for our times

Science literacy is necessary for all citizens today. In the workplace, citizens need technical abilities, problem-solving skills, and the ability to think critically and to learn effectively. In private life, citizens must incorporate scientific information into decision making. In a democracy, citizens must intelligently engage in public discourse about issues related to science and technology. Hence, elementary, middle, and high-school science education must give the high-school graduate knowledge of science content, appreciation of science-society challenges, and the ability to employ scientific thinking and problem-solving skills.

IV. The revised New Mexico Science Standards

The revised New Mexico Science Standards[2] are organized in three "strands," Scientific Thinking and Practice, Content of Science, and Science and Society, similar to the three main paragraphs of section II of this paper. In each strand, important concepts are introduced in Kindergarten and are revisited with ever-increasing sophistication through high school. For example, the concept of "matter" begins in Kindergarten with "Observe that different materials have different properties (e.g., color, odor)" and builds steadily to include topics such as the structure of atoms.

Content of Science: In this strand, unity among the science subject areas, here organized around physical sciences, life sciences, and earth-and-space sciences, is exemplary. The most important fundamental, unifying concepts, such as conservation of matter and energy, run throughout the subject areas and are revisited over and over with more sophistication from grade level to grade level. The biochemical aspects of life sciences and the way that the principles of physics and chemistry support earth and space science are evident. By sticking with the most important central concepts, and revisiting them again and again with increasing sophistication from grade to grade, the standards strike a good balance: neither too little content nor too much.

Science and Society: This strand is admirably strong in the revised New Mexico science standards. We expect that it will bring excellent motivation and interest to the science classroom. The Science and Society strand introduces current events related to science and technology, the role of scientific knowledge and methods in helping individuals and societies make decisions, and near-philosophical issues (such as how individuals can incorporate scientific thinking with other ways of knowing, and how individuals and societies determine whether technology is used for good purposes or bad ones). This strand is innovative, and we believe it will promote mature thought, provide motivation for science, and prepare students for participation in a democratic society and for other adult roles.

Scientific Thinking and Practice: This strand builds a broad foundation for many critical thinking skills every adult should have. With respect to science itself, the standards include a systematic buildup to the centrality of the "testable hypothesis" in science. This concept helps distinguish science from other approaches to human knowledge and separates science from superstitions that falsely claim predictive power, such as astrology. The nature of science as a continually re-evaluated, revised body of knowledge is clearly presented, so students can understand that science makes no claim of reaching a complete and final truth even while it has demonstrated an unsurpassed ability to predict what happens in the natural and man-made world. Logic and the use of mathematics are evident throughout, and one can hope that students will gain the ability to evaluate claims critically and form intelligent opinions.

These are called "strands" because they are meant to be interwoven in curriculum. If the revised New Mexico Science Standards are adopted and used to guide curriculum, they will indeed produce high-school graduates who know enough of the content of science to function effectively in our complex world and our tech-based workplaces, who appreciate the relevance of science to their lives, who can form intelligent opinions about societal and individual issues involving science and technology, and who understand the unity of science.

Footnotes and citations

1. The Fellows are a group of senior LANL scientists and engineers who have been recognized by the Director for their outstanding technical accomplishments. Fellows come from throughout LANL, span a wide range of scientific and engineering backgrounds, and contribute broadly to national security, applied research, and fundamental research. Fellows cannot be members of LANL management. Today there are 68 active Fellows, a number that is limited to about 2% of LANL scientists and engineers.

2. New Mexico Science Content Standards, Benchmarks, and Performance Standards, Final Draft, Revised 2003, New Mexico Department of Education. August 13, 2003.

3. Data from LANL Human Resources Division, Workforce Data and Analysis Group, July 2003. Total population: 7988 UC-LANL employees.