Critical Path to Nuclear Science and Technology Knowledge Transfer and Skill Development in K-12 Schools: Why America Needs Action and Support from Federal and State Education Departments Now

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ABSTRACT

With the signing of President Bush’s energy bill in August of 2005, the successful application of the new energy legislation may have more to do with educational standards required in our schools than applications of research and technology in the long-term. Looking inside the new legislation, the future of that legislation's success may not just hinge on investment in technology, but ensuring that our citizens, especially our youth, are prepared and better informed to be able to understand, react, and apply the economically and national security driven intent of the law. How can our citizens make sense of change if they lack the skills to be able to understand, not only the technology, but also the science that drives the change?

President Bush’s passage of the 1,724-page bill emphasizes conservation, clean energy research, and new and improved technology. The legislation also provides for economic incentives toward building more nuclear power plants. This paper will use four questions as a focal point to emphasize the need for both state and federal education departments to review their current standards and respond to deficiencies regarding learning about radioactivity, radiation, and nuclear science and technology. The questions are:
1. Will America accept new nuclear power development?
2. Will waste issues be resolved concerning high- and low-level radioactive waste management and disposal?
3. Will nuclear “anything” be politically correct when it comes to your backyard?
4. Is our youth adequately educated and informed about radioactivity, radiation, and nuclear science and technology?

This paper will use Pennsylvania as a case study to better understand the implications and importance of the educational standards in our school systems. This paper will also show how the deficiency found in Pennsylvania’s academic standards, and in other states, has a significant impact on the ability to fulfill the legislation's intent of realizing energy independence and national security.

INTRODUCTION

Addressing the questions

<u>1. Will America accept new nuclear power development?</u>

Conventional wisdom says maybe. Timing, location, status of security, national and local politics--especially regarding licensing or disposal, and the cost of building a new plant are just some issues that may face this question. Don’t forget local issues, TMI and Chernobyl, and the general lack of education about nuclear science by the public.

2. Will waste issues be resolved concerning high- and low-level radioactive waste management and disposal?
High-level waste is mired in politics at the federal and state levels with the cry for more study and the timeline toward operational status keeps being pushed backward.

Low-level radioactive waste (LLRW) was set back indefinitely when the US Supreme Court on June 19, 1992, upheld regional compacts, sited states' authority, but overturned the take-title provision. The provision of the LLW Policy Act Amendments Act of 1985 removed a state's responsibility of having to dispose low-level waste issues within its border. This rule has made the original LLW Policy Act of 1980 ineffective. Only a crisis may change the need to resolve LLW issues at a national level. Until then, it will be private or individual compact initiatives that will of disposal continue LLRW in the United States. [1]

3. Will nuclear "anything" be politically correct when it comes to your backyard?
Depends on the public's choice of some well used acronyms on this subject:
NIMBY: Those who were adamantly opposed to having a LLRW site built-- "Not In My Back Yard!"
NIMTOO: Elected officials who believe that a facility should not be in operation within their district or state--"Not In My Term Of Office!"
NOPE: "Not On Planet Earth!" the term and actions speak for itself.
BANANAs: "Build Absolutely Nothing Anywhere Near Anything!" Like the above, opposition is the answer.
NIMBI: A term rephrased from the negative NIMBY into a more proactive and questioning term meaning "Now I Must Become Involved." This term does not preclude site development, but allows study, discussion, learning, and meaning resolution of the subject. [2]

4. Is our youth adequately educated and informed about radioactivity, radiation, and nuclear science and technology?
No! Based on the academic standards adopted by the federal and state governments our youth will continue to be under served. Our youth need objective information at the elementary and secondary level that can help demystify radiation and radioactivity, nuclear science and its multitude of applications, and the management and generation of nuclear energy.

AMERICA'S NEED FOR NUCLEAR SCIENCE EDUCATIONAL REFORM

America's ability to deal with controversial and risk-based technology has been one-sided. It has been actuated by government and government alone that has determined how such technology goes from research into application.

America provides little to no formal education during the formative years of elementary school on such topics as nuclear science and technology, energy systems such as nuclear power, and the basics of radiation. Even at the secondary level of education, our schools provide few comprehensive courses on risk-based technology. Compared to the number of children in our public schools, only a small fraction of selected secondary students are educated on such topics.

The development of America's nuclear energy since World War II into the 1970s flowed through government channels with little public or political input. However, this should not be the case in the 21st Century. It is therefore the premise of this paper that America must change it standards to better educate its youth to provide for a more informed electorate to help make the decisions in the future.

[1] ACURI Newsletter, July 1992, No.49, pp.1-2
[2] Kenneth Miller, 2002 US Department of Defense Rad Conference, "When Attempting to Site a Low-Level Radioactive Waste Disposal Facility You Quickly Learn that The World is Full of BANANAs")

Today, we cannot expect teachers to teach about nuclear science and technology, energy systems, or about radiation and radioactivity unless they are required as part of academic educational standards. In reviewing science standards in most states, teaching such subjects occurs in upper level classes and curriculums in high schools. In other words, subjects not for the masses. Another major issue is that few college educational majors are being taught about nuclear science or risk-based technologies as part of their teaching certification courses. [3, 4]

THE PRESIDENT'S INITIATIVE

President Bush's passage of his energy initiative legislation in August of 2005 faces many public and political hurdles. If the economic incentives in the legislation will make provide for more nuclear power plants, the public will need to be better informed and educated about the subject during the state and local government process of building a plant and related services, including transportation and disposal of wastes. Given today's political climate and the controversy over nuclear energy since the accidents at Three Mile Island and Chornobyl, the inability of states to meet the 1980 and 1985 Low-Level Radioactive Waste disposal initiatives, and continued delays at the High-Level Waste repository at Yucca Mountain, the ability to site or operate anything that is related to nuclear science and technology is not simple or easy.

Science and technology, which has brought the United States unprecedented energy resources and financial rewards, had a partner in the process—politics, which does not depend necessarily on the scientific method when determining the extent of the application. Therefore, nuclear science and technology, energy systems, radiation, and radioactivity should be studied, discussed, debated, and taught in our schools. Not just in upper level physics or chemistry high school classes, but throughout our K-12 educational system.

THE EARLY YEARS OF NUCLEAR ENERGY DEVELOPMENT

In reviewing a number of books and other sources regarding the history and development of nuclear energy development, the writings of Alvin M. Weinberg were most helpful in understanding how nuclear science and technology became part of our world. In his essays and comments, Dr. Weinberg detailed how our federal government and its related agencies were the prime mover, motivator, controller and director of the development of nuclear energy in the United States and the rest of the world.

In 1985, the American Nuclear Society (ANS) published a book entitled, "Continuing the Nuclear Dialogue, Selected Essays by Alvin M. Weinberg." This book provided much insight into the development of nuclear energy. Weinberg's role, in itself, has been noteworthy in reactor development for energy purposes. His early work at the University of Chicago in the early 1940s made him one of the pioneers in fission reactors development. Dr. Weinberg's study in submarine application of pressurized nuclear reactors was important as America moved into the post World War II era. Weinberg's other contribution came during his years at Oak Ridge National Laboratory and other federal agencies and affiliated institutions that made him a change agent that supported the development of today's nuclear energy plants. For over three decades, Dr. Weinberg served as a Research Director or Director of many federal laboratories or associated research and development organizations. [5]

An essay he wrote in 1946, which appeared in "The New Republic" entitled "Atomic Power: Next Steps" came from his testimony before the U.S. Senate's Special Committee on Atomic Energy. Dr. Weinberg's comments were futuristic to say the least. "In the long run we can expect nuclear fission to compete on a strictly economic basis with ordinary power source." [6]

[3](http://www.pde.state.pa.us/stateboard_ed/cwp/view.asp?a=3&Q=76716&stateboard_edNav=|5467|&stateboard_edNav=|)
[4] http://www.psu.edu/bulletins/bluebook/major/seced.htm
[5] American Nuclear Society (ANS), "Continuing the Nuclear Dialogue Selected Essays by Alvin M. Weinberg, 1985, Biography.
[6] Ibid, p.3.

He went on to say, “Right now there are two problems hampering the development of atomic power. First, because of security, because of general uncertainty, we are sadly short of training personnel…estimated that there are not more than fifteen men in the entire county who have at this moment a sufficiently quantitative grasp of the progress adequately to direct the development of new nuclear power plant…The second problem is more serious…the profound international implications of atomic energy. The international aspects will determine our domestic atomic energy development, since a satisfactory control system will enable us to relax our security regulations and atomic power will develop normally.” [7]

From that early interaction with federal government officials, funds were provided through national laboratories and other agencies to continue research on the atom. By 1954, Weinberg wrote that “the United States had committed itself to developing economically competitive nuclear power—but we were by no means certain that the goal of cheap nuclear power was achievable. Safety and reliability had to be demonstrated.” [8]

In his 1954 essay, Dr. Weinberg emphasized the attributes of nuclear power by providing his readers with the “unique properties of a nuclear chain reaction.” “1. …nuclear chain reaction regenerates its fuel supply, referred to his choice of a breeder reactor…2. …requires no oxygen. 3. …extraordinarily compact. 4. …rate of energy evolution in a neutron chain reaction is rather independent of temperature, unlike a chemical fire.” [9]

Weinberg also pointed out that the success of nuclear submarine research and proven development of the Nautilus and Sea Wolf paved the way for two companies to emerge and be prepared to develop nuclear power plants for commercial electricity purposes. The companies were the Electric Boat Division of General Dynamics Corporation and Westinghouse. [10]

ATOMS FOR PEACE PROGRAM

The first commercial central electric-generating station in the United States was at the Shippingport Atomic Power Station, Shippingport, Pennsylvania, nearly 50 years ago. Started during President Dwight D. Eisenhower’s administration, the reactor plant was part of Eisenhower’s “Atoms for Peace” program.

The “Atoms for Peace” program was actually formulated during the presidency of Harry S. Truman. In a post-war 1945 message, Truman made mention of applications of nuclear science other than weapon development by encouraging the use of “atomic energy and all future scientific information toward peaceful and humanitarian ends.” Truman also proposed the creation of the Atomic Energy Commission (AEC). The AEC was the precursor of today’s Department of Energy (DOE) and Nuclear Regulatory Commission (NRC). Truman’s AEC was not only allowed to do research and encourage nuclear development, but also regulate it. [11]

The formation of the AEC, and at the same time sharing such information with other countries, started a commercial race, actually worldwide, to see who could develop the first commercial reactor and produce this new form of energy from the atom. By the time Dwight Eisenhower became president, the Cold War was in full swing. President Eisenhower, seeing the growing tensions between the Soviet Union and the United States, developed with his staff and cabinet secretary a “uranium bank” governed by an Atomic Energy Agency (later to become the International Atomic Energy Agency (IAEA) created by the United Nations in 1957). Eisenhower’s actions devised ways to limit uranium resources by focusing on “uranium for peaceful purposes like agriculture, medicine, and especially to provide for abundant electrical energy in the power-starved areas of the world.” [12]

The 1953 Atoms for Peace program famous speech was successful in making the public aware of the application of nuclear science and technology. The program opened the door for national labs and private industry to develop the technology. [13]

[7] Ibid, p.8.
[8] Ibid, p.9.
[9] Ibid, pp.10-11.
[10] Ibid, pp.10-11.
[11] Weiss, Leonard, “Bulletin of the Atomic Scientists,” November/December 2003 pp. 34-41, 44 (vol. 59, no. 06)
[12] Ibid, pp.34-41.
[13] Ibid, pp.34-41.

The public had little or nothing to say about nuclear developments during the late 1930s and into the 1950s. America had just gone through a terrible World War. By the time the Atoms for Peace program began the United States was well into the Cold War with the Soviet Union. The Atoms for Peace program came to us while our schools taught little or nothing about nuclear science or technology. Then how did America learn about nuclear anything? The answer again is the government's use of mass media as an educational tool. [14]

WALT DISNEY EDUCATES AMERICA—OUR FRIEND THE ATOM

Many people attribute their understanding of nuclear science and technology to one man, Walt Disney. Disney had a long, established interaction with federal government. The famous animator made many films that deemed propaganda, training and for educational purposes. As Disney, his famous cartoon characters, and his savvy business acumen grew, Walt Disney productions moved into new ventures and companies that applied animation, live-action films, licensing production promotions, toys, printing and publications, movies, and television. [15]
One of the most memorable applications of the Atoms for Peace program was Disney's famous "Our Friend the Atom." This animated film was produced by Disney in cooperation with the U.S. Navy and General Dynamics. They were the builders of the nuclear submarine USS Nautilus. To prove the power of Disney's capabilities of getting the message out, "Time magazine reported in 1954, almost one billion people worldwide has seen at least one Disney film." [16]

Walt Disney went one step further in sending the government nuclear message to the public. In 1959, "the largest atomic submarine fleet in the world was owned by Walt Disney—a ride at his Anaheim, California park called Disneyland's Tomorrowland. The ride, costing $2.5 million to develop included eight air-conditioned "atomic" submarines. At its opening on June 14, 1959, the event included ABC television, Vice-President Nixon and other US Navy dignitaries. [17]

How successful was Mr. Disney in "educating" Americans about the atom and its applications, peaceful and otherwise? According to Mark Langer, the Christian Science Monitor wrote, "all these things were turned, by Disney magic and with Disney color, to sheer fun, as though the real purpose of technological achievement, after all, was human happiness." [18]

CHALLENGES TO A NEW AND GROWING NUCLEAR ENERGY INDUSTRY

Alvin Weinberg's next essay of note in regard to this paper was written in 1971. Dr. Weinberg wrote it before "Rasmussen had completed his analysis of the probabilities and consequences of serious reactor accidents. [19]

In a table that he titled "Problem of Nuclear Energy" he outlined seven areas of concern. It is important to note that he was an advocate for plutonium breeder reactors. The seven categories that he stated in the 1971 essay were also prefaced by the following statement, "I believe that we have come up with answers to each of these questions that are entirely acceptable as long as the enterprise is relatively small."

1. Safety of reactors, related to the vessel's containment capability;
2. Transport of radioactive fuel; he advocated central nuclear parks to limit accident rates or potential theft (or in today's terminology terrorist activities);
3. Ultimate disposal of radioactive wastes; Weinberg advocated solidification and disposal in salt;
4. Clandestine diversion of fissile materials, as with the area of transport, Weinberg felt that centralized systems would minimize the threat;

[14] Interview - Penn State Nuclear Engineering Professor Emeritus, Warren F. Witzig, Ph.D., March 15, 2002
[15] Langer, Mark, http://www.awn.com/mag/issue3.1/3.1pages/3.1langerdisney.html)
[16] Ibid.
[17] Ibid.
[18] Ibid.
[19] Ibid.

5. Disposal of old reactor site; Weinberg asked the question of decontamination and wanted this subject to be taken seriously by developers;
6. Waste heat; Weinberg did not see reactors adding much to global warming; and
7. Waste by-products of mining uranium; Dr. Weinberg's comparison to other forms of mining and their spoil led to his comment, "Disposal…does not seem to be an especially formidable task." [20]

What is important to note is that Weinberg's comments were addressed to other scientists and government officials. The discussion was not part of a public forum or discussed in schools by tomorrows leaders and scientists.

NUCLEAR ENERGY IN RETREAT

"By 1977, nuclear energy was in retreat. The Brown's Ferry fire has affected the public at large." A study on the "Economic and Environmental Implications of a Nuclear Moratorium, 1985-2010" concluded that the abundance of coal in the United States for the next 30 years would require that the industry consider restructuring itself. [21]

Dr. Weinberg, in a lecture to Purdue University nuclear engineering students in 1976, later appeared in the "Bulletin of the Atomic Scientists." Weinberg said, "The acceptability of nuclear energy is shadowed by doubt, is painful to those of us who have devoted our careers to peaceful nuclear energy. Twenty-five years ago, we were hailed as harbingers of a new and abundance age based upon nuclear energy…" Weinberg during his lecture asserted that a noted politician allegedly asserted, "Easier to scare people than it is to unscare them." [22]

Weinberg's remarks to the young engineers highlighted economics and environmental impacts in comparison to coal. He concluded his talk by stating, "Nuclear reactors when properly operating represent a superb long-term source of prime energy: they are probably as cheap as, if not cheaper, and do less violence to the environment than any other large scale prime source of thermal energy." [23]

In outlining the hazards associated with nuclear reactors, Weinberg did state that they do "produce immense amounts of radioactivity; plutonium is an explosive; and reactors will not always operate properly." He went on to speak about the possibility of an accident that could likely shutdown the industry. He concluded, yes, and that the probability of having a serious accident is not easily quantifiable, but a function of what would happen during an incident that was not managed properly. [24]

The accidents at Three Mile Island in 1979 and at Chernobyl in 1986 would prove Weinberg's point in that both accidents were due to operator error and not the machine's design or capability.

Dr. Weinberg's comments on public sentiments were quite poignant for the day (1976). He said "There is a general distrust of big technology…nuclear energy began as a military enterprise…early applications of plutonium production at Hanford caused wastes to leak from tanks." Weinberg then discussed differences regarding several risk-based technologies. When put the question "Is nuclear energy acceptable?" he said yes, given 1976, but went on to say, "Assuming that no other inexhaustible and convenient source of energy has been developed, we shall turn to the breeder." [25]

One interesting point found in his 1976 paper was how Weinberg proposed to change or restructure the industry. He posed a question, "how can we create the professionalized cadre that I believe is demanded by nuclear energy?" His response was to "separate distribution and marketing of electricity from its generation." [26]

[20] American Nuclear Society (ANS), "Continuing the Nuclear Dialogue Selected Essays by Alvin M. Weinberg, 1985, p. 59.
[21] Ibid, pp. 63-66.
[22] Ibid, p.73.
[23] Ibid, p.74.
[24] Ibid, p.75.
[25] Ibid, p.76.
[26] Ibid, pp.85-86.

REGARDING EDUCATION

At an international meeting in 1977, Dr. Weinberg spoke about education, specifically preparing nuclear engineers, but his paper has an uncanny connection to preparing coming generations to understand nuclear science and technology and appreciate as he called it, "the full sense of the responsibility they bear" using the technology. [27]

Regarding education, Weinberg addressed his perception of nuclear energy and the public in having two major problems. He said they were "immense radioactivity and connection with nuclear weapons." He went on to say, "In the public's mind 100mR per year is as mysterious and, I suppose, as threatening as 100R…The public has a primitive, instinctive fear of radiation primarily because to them it is mysterious. If we are to make nuclear energy fully acceptable, we shall have to deal with these primitive perceptions of danger, as well as the real dangers of nuclear energy." [28]

During this period, Weinberg and other scientists did advocate for more education on risk-based technologies. Weinberg argued that the public has little understanding of probable risk assessment or the implications of designing a nuclear power plant that will have "no significant probability" of a catastrophic accident. It is not practical or economically feasible to respond to demands for a totally safe reactor "without putting realistic limits to what can or cannot be accomplished by technology." [29]

Former director of the Harvard School of Public Health's Center for Risk Analysis, John Graham, Ph.D., found that most Americans believe that things in the environment are at least as important as personal habits when it comes to causing illness and poor health. One study found 85 percent of all deaths could be linked to unhealthy lifestyles which only 15 percent were caused by environmental agents. "Perhaps it's just human nature to want to blame our health problems on someone or something else rather than take responsibility for them ourselves." Graham, however, says, "the media shares at least part of the blame for Americans' misperceptions about environmental health risks." [30]

In a five year study by the National Science Foundation (NSF), it was found that when science and technology are taught in an object manner only, such practices cause students to not learn the relationship between science and technology. Therefore, students are unaware of the roles that research and development play in an industrialized society. [31]

Today's national and state academic standards have changed relatively little in regard to teaching about nuclear science and technology, energy systems, radiation, and radioactivity since the 1980s. Given the recent energy shortages, Homeland issues such as dirty bombs, the increasing costs of fossil fuels, and President Bush's initiative to develop new nuclear energy plants, it is time for America to educate future generations. Teachers can make a difference in creating a future electorate that will not base their understanding about risk-based technologies as nuclear energy without having a sound foundation in radiation, nuclear science and technology. They will has be able to learn critical thinking skills that will enable them to make a wise decision based on fact after weighing both sides of a controversy. We should not short-change our teachers either.

Political scientist Dr. Jon D. Miller is the director for the Center for Biomedical Communications at Northwestern University Medical School in Chicago. In an article published on August 30, 2005, in The New York Times, Dr. Miller said, "While scientific literacy has doubled over the past two decades, only 20 to 25 percent of Americans are 'scientifically savvy and alert'…at a time when science permeates debates on everything from global warming to stem cell research, people's inability to understand basic scientific concepts undermines their ability to take part in the democratic process." Regarding the subject of radiation, his Center found that only 10 percent know what radiation is. "Our best university graduates are world-class by any definition…but the second half of our high school population-it's an embarrassment. We have left behind a lot of people." [32]

[27] Ibid, pp.90.
[28] Ibid. pp. 91-92.
[29] Ibid, p.131.
[30] ACURI Newsletter, November 1994, No. 78, p.5.
[31] J.Vincenti and J.Shillenn, "Nuclear power ... education." Penn State University, 1982.
[32] Corneila, Dean, "Scientific Savvy? In U.S., Not Much," The New York Times, August 30, 2005

The authors of this paper do not advocate placing blame on teachers or the curriculum. We believe as this paper has demonstrated that it is a political and educational leadership problem. When a teacher does not teach about radiation, nuclear science or technology, it is more a function of not being required to do so as part of the academic standards found at federal or state levels. Therefore, if the standards do not require the subjects to be taught, then the problem grows into a cause and effect systems problem. Conversely, teachers who teach teachers in our colleges and universities will not place an emphasis on such subjects, or make it a required course for majoring in science or social science. Therefore, when students enter the field of education in our schools, they are not prepared to address or even care to teach such subjects.

NATIONAL SCIENCE EDUCATION STANDARDS

In 1996, the National Science Education Standards were adopted. These standards were designed to ensure that every student received a wide variety of experiences which would lead to scientific literacy and the ability to make informed decisions in an increasingly complex society.

The National Science Education Standards make the following references to nuclear science and energy generation:
Content Standard B: Physical Science
Properties and Changes of Properties in Matter – Structure of Atoms
- References are made to nuclear reactions, fission, fusion and radioactive isotopes. A reference to radioactive dating is also made.

Content Standard B: Physical Science
Transfer of Energy – Conservation of energy and increase in disorder
- References to kinetic and potential energy are found. Conservation of energy is mentioned, but is used in the context of physics problems where energy is transferred from one object to another.

Content Standard F: Science in Personal and Social Perspectives
Populations, Resources and Environments.
- In this standard natural resources are mentioned [33]

PENNSYLVANIA: A CASE STUDY

In 2002, Pennsylvania adopted its Academic Standards for Science and Technology, Environment, and Ecology. The Standards table of contents is titled with key words that would seem ideal for students to learn about various subjects including those related to nuclear science. The Standards titles are: Unifying Themes, 3.1; Inquiry and Design, 3.2; Biological Sciences, 3.3; Physical Science, Chemistry and Physics, 3.4; Earth Sciences, 3.5; Technology Education, 3.6; Technological Devices, 3.7; and Science, Technology and Human Endeavors, 3.8. An additional nine standards exist for Environment and Ecology. [34]

The Standards define science as "the search for understanding the natural world and facts, principles, theories and laws that have been verified by the scientific community and are used to explain and predict natural phenomena and events." It defines technology education as being "divided into three main systems biotechnological, informational, and physical technologies."

[33] http://www.nap.edu/readingroom/books/nses/html/overview.html
[34] Pennsylvania Department of Education Academic Standards

The Pennsylvania Science Standards for Science, Technology, Environment, and Ecology (STEE) for Kindergarten through Grade 12 include the following references to nuclear science and energy resources and generation are:

3.4.10. **GRADE 10**
- Describe the nuclear processes involved in energy production in a star.

3.7.10. **GRADE 10**
- Describe and demonstrate the operation and use of advanced instrumentation in evaluating material and chemical properties (e.g., scanning electron microscope, nuclear magnetic resonance machines).

3.8.10. **GRADE 10**
Compare technologies that are applied and accepted differently in various cultures (e.g., factory farming, nuclear power).

3.2.12. **GRADE 12**
A. Evaluate the nature of scientific and technological knowledge.
- Critically evaluate the status of existing theories (e.g., germ theory of disease, wave theory of light, classification of subatomic particles, theory of evolution, epidemiology of AIDS).

3.4.12.B **GRADE 12**
Physical Science, Chemistry and Physics Apply and analyze energy sources and conversions and their relationship to heat and energy.
- Apply appropriate thermodynamic concepts to solve problems relating to energy and heat.

3.4.12 **GRADE 12**
A. Apply concepts about the structure and properties of matter.
- Classify and describe, in equation form, types of chemical and nuclear reactions.
- Apply the conservation of energy concept to fields as diverse as mechanics, nuclear particles and studies of the origin of the universe.
- Apply the predictability of nuclear decay to estimate the age of materials that contain radioactive isotopes.

D. Analyze the essential ideas about the composition and structure of the universe.
- Analyze the Big Bang Theory's use of gravitation and nuclear reaction to explain a possible origin of the universe. [35]

Note: While not specifically stated, nuclear science topics would have to be taught in order to teach the above standards. To teach the balancing of equations, basic types of radiation (alpha, beta and gamma) would have to be discussed. Hopefully their properties and sources would also be addressed. Radioactive dating cannot be discussed without teaching the concept of half-life. This concept is also important in the discussion of the storage and disposal of radioactive waste.

4.2.7A **GRADE 7**
Renewable and Nonrenewable Resources
- Know that raw materials come from natural resources (fossil fuels).

4.2.10A **GRADE 10**
Renewable and Nonrenewable Resources
- Explain that renewable and nonrenewable resources supply energy and materials.

4.2.12.A **GRADE 12**
Renewable and Nonrenewable Resources
- Analyze the use of renewable and nonrenewable resources.

4.2.12.B **GRADE 12**
Renewable and Nonrenewable Resources
- Analyze factors affecting the availability of renewable and nonrenewable resources. [36]

Note: While these two standards seem to be getting closer to the concept of fossil fuels as nonrenewable resources, they are never specifically stated.

[35] Ibid.
[36] Ibid.

PENSYLVANIA STANDARDS ARE MODIFIED

In late summer 2005, Pennsylvania modified its Academic Standards for Science, Technology, Environment, and Ecology. The modified documents are now entitled, "Assessment Anchors and Eligible Content." They were released for grades 4, 8 and 11.

The reason for the change was based on an analysis done by the Pennsylvania Department of Education. In an address at the 2003 Pennsylvania Science Teacher's Association annual conference, Pennsylvania's Secretary of Education, Dr. Vicki Phillips, stated that Pennsylvania's science standards were "a mile wide and an inch deep." Teachers in the audience were told that "key standards" would be modified. The goal for the change was to reduce the number of Standards into a more achievable and manageable format. The modified Standards, "Assessment Anchors and Eligible Content" will be tested on the state science tests for those grade levels. Teachers are supposedly going to teach all of the standards but only the "anchors" will be tested in 2007. This first round of tests will be used to determine the scores needed to "pass" the 2008 testing. In effect, the Commonwealth of Pennsylvania has reduced it academic standards. For example, for Grade 11, the number of pages went from approximately 60 pages to 16 pages. [37]

STANDARDS SHORT CHANGE ENERGY AND NUCLEAR SCIENCE

In modified Academic Standards, the Pennsylvania Department of Education has no reference to nuclear science topics as previously identified in the original standards.

In Assessment Anchor S11.C.1 Structure, Properties, and Interaction of Matter and Energy, the term "nuclear" does not appear - thus no equations and no radioactive dating.

Assessment Anchor S11.C.2 Forms, Sources, Conversions, and Transfer of Energy does address alternative forms of energy and renewable (wind, solar, and biomass) energy sources – but nuclear energy is not listed.

Since these are the standards that will be tested and in all likelihood the ones that will be taught, the future for nuclear science education as well as general energy education in Pennsylvania is not very bright. [38]

THE CHALLENGE

Pennsylvania was used as a case study because it is what the authors are most familiar with. Our research has found that Pennsylvania is not unique in this matter.

In the past few years, the United States has faced rolling brownouts in California, a major blackout on the east coast, and disruptions to petroleum supplies and natural gas due to natural disasters. The demands for petroleum are expected to increase as Asian economies grow. If we want educated citizens, science standards should include energy standards that really address the issues.

We suggest the following energy topics be included in current standards, but distributed so that children from Kindergarten through grade 12 will learn about energy:

- Current sources and resources of energy
- The energy conversions involved when one form of energy is converted to another
- How electricity is generated
- Controversial and risk-based technologies

[37] http://www.pde.state.pa.us/a_and_t/cwp/view.asp?a=108&q=103127&a_and_tNav=|
[38] http://www.engr.psu.edu/etp/youngengineersandscientists2005.pdf

- Renewable and nonrenewable energy sources
- Waste management and disposal issues
- Advantages and disadvantages of the various energy sources
- Sustainability in regard to various forms of energy
- Emerging energy sources such as hydrogen and fuel cells
- Methods of energy conservation
- National and global issues

There are many excellent instructional tools that have been developed by the American Nuclear Society, Health Physics Society and other governmental and non-governmental groups to educate youth about nuclear science and radiation. These should be carefully reviewed and incorporated into curriculum programs.

Another programmatic approach has been demonstrated in a program started in late 2002 through the US DOE and the Innovations and Enhancements for a Consortium of Big Ten University Virtual/Research and Training Reactors. The program built into the entire grants was called Mini-Grant Program. The program provides for annual grants from $1,000 to $25,000 to businesses, colleges, DOE national laboratories, high schools and industry. With an emphasis on receiving and funding high schools, this Program helps teachers and their students delve more into nuclear science and technology by allowing them to apply for their specific curriculum and program needs.

The Program over the past three years has enabled thousands of youth throughout the United States and even an American school in South Africa to gain invaluable learning experience. Each grant proposal is reviewed by three different groups before the final approval is granted by the DOE. Some grants have included educational visits, other purchasing equipment for in-school experiments. Other grants have included reactor analysis of studies done at the home school.

One grant led to the development of a summer week-long program called “Young Engineers and Scientists (YES). YES was developed as an additional enhancement of the Westinghouse Science Honors Institute (WSHI) in Pittsburgh, Pennsylvania. WSHI had received a Mini-Grant for weekend programs for students at the Penn State Breazeale Reactor. YES provided an opportunity for selected students from that program to spend a week at Penn State for more extensive study and experimentation plus an opportunity to be with Nuclear Engineering graduate students who met with them during the week and also lived with them in the dormitory during the program. [38]

The Big Ten consortia universities with training and virtual research reactors involved in the Mini-Grant Program consist of Penn State (the principal organization), University of Illinois at Urbana-Champaign, University of Michigan, Ohio State University, University of Purdue, and Wisconsin-Madison. [39]

The United States currently relies upon nuclear energy for at least 20 percent of its electricity. In regard to President Bush’s initiative on building new nuclear power reactors, it would seem that now is the best time to include nuclear science and technology as part of our science curriculums in both elementary and secondary schools.

If Pennsylvania reduces its statewide academic standards in science, technology, environment, and ecology, then what can we expect from our citizen-students in the future in being able to make informed decisions in our country?

CONCLUSION

We encourage organizations such as the American Nuclear Society, Health Physics Society, and other groups such as the American Nuclear Institute and the National Science Teachers Association to take a closer look into this matter and support the need for more energy education, nuclear science and technology, radiation, and radioactivity to be taught in our schools. This will not be a simple change, but it can and will impact every person throughout the United States and worldwide.

[39] http://www.mne.psu.edu/minigrant/

REFERENCES

1. American Nuclear Society (ANS), "Continuing the Nuclear Dialogue Selected Essays by Alvin M. Weinberg, 1985
2. ACURI Newsletter, ACURI Association, Inc., July 1992
3. Corneila, Dean, "Scientific Savvy? In U.S., Not Much," The New York Times, August 30, 2005
4. Internet: http://www.engr.psu.edu/etp/youngengineersandscientists2005.pdf
5. Internet: http://www.pde.state.pa.us/stateboard_ed/cwp/view.asp?a=3&Q=76716&stateboard_edNav=|5467|&stateboard_edNav=|
6. Internet: http://www.mne.psu.edu/minigrant/
7. Internet: http://www.nap.edu/readingroom/books/nses/html/overview.html
8. Internet: http://www.psu.edu/bulletins/bluebook/major/seced.htm
9. Internet: Langer, Mark, http://www.awn.com/mag/issue3.1/3.1pages/3.1langerdisney.html
10. Interview - Penn State Nuclear Engineering Professor Emeritus, Warren F. Witzig, Ph.D., March 15, 2002
11. Miller, Kenneth, 2002 US Department of Defense Rad Conference speech, "When Attempting to Site a Low-Level Radioactive Waste Disposal Facility You Quickly Learn that The World is Full of BANANAs"
12. Pennsylvania Department of Education, Academic Standards
13. Report: J.Vincenti and J.Shillenn, "Nuclear power in the classroom: a union of science and social studies education." Penn State University, 1982
14. Weiss, Leonard, "Bulletin of the Atomic Scientists," November/December 2003 pp. 34-41, 44 (vol. 59, no. 06)