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Preparing Youth For A Basic Understanding Of Science & Technology In The Scope Of Education: What Can Be Done?

Youth Civic Leaders Summit – March 2-4, 2012
Youth-Led Issues Forum – "Science" Track
Background Information

Summary of Problem

In the growing global marketplace, students will need to excel in both math and science to compete internationally as engineers, scientists, physicians, and creative entrepreneurs. Yet, in an assessment by the Organization for Economic Cooperation and Development, 15-year-olds in the U.S. placed 25th out of 30 countries in math performance and 21st in science performance.

http://www.studentsfirst.org/pages/the-stats

According to a recent report by the National Science Board (NSB), the United States remains the global leader in supporting science and technology (S&T) research and development, but only by a slim margin that could soon be overtaken by rapidly increasing Asian investments in knowledge-intensive economies. According to the new *Indicators 2012*, the largest global S&T gains occurred in the so-called "Asia-10"--China, India, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Taiwan and Thailand--as those countries integrate S&T into economic growth. Between 1999 and 2009, for example, the U.S. share of global research and development (R&D) dropped from 38 percent to 31 percent, whereas it grew from 24 percent to 35 percent in the Asia region during the same time.

In China alone, R&D growth increased a stunning 28 percent in a single year (2008-2009), propelling it past Japan and into second place behind the United States. "Over the last decade, the world has changed dramatically," said José-Marie Griffiths, chair of the NSB committee that oversees production of the report. "It's now a world with very different actors who have made advancement in science and technology a top priority. And many of the troubling trends we're seeing are now very well established."

January 17, 2012, National Science Foundation Press Release
http://www.nsf.gov/news/news_summ.jsp?cntn_id=122859

National and state education policies continue to focus on improving learning by U.S. students. Policy goals include increasing student achievement overall, reducing disparities in performance among key subgroups of students, and moving the international ranking of U.S. students from the middle to the top over the next decade. STEM fields (science, technology, engineering, and mathematics) have been a strong focus of recent reform efforts, including developing common core standards across states, strengthening curricula, promoting advanced course taking, enhancing teacher quality, raising graduation requirements, and expanding technology use in education.

The National Assessment of Educational Progress (NAEP), a congressionally mandated program, has monitored changes in U.S. students' academic performance in mathematics and science since 1969. The main NAEP assesses national samples of 4th and 8th grade students at regular intervals and 12th grade students occasionally. Likewise, the OECD has instituted a three year cycle for looking at reading, mathematics, and science for 15 year olds, called the PISA studies—The Program for International Student Assessment.

"A sobering report on the performance of American students relative to their peers in other countries should be a wake-up call for the nation, Secretary Duncan said Tuesday (12/08/10).

The latest scores of the world's 15-year-olds on an international test of reading, math and science show the United States is merely an average performer, whose growth during this time of rising demand for highly educated workers has been stagnant. The good news, Duncan said, is that the U.S. is now pursuing education reforms that are hallmarks of top-performing countries, including high standards and investment in effective teaching.

"The mediocre performance of America's students is a problem we cannot afford to accept and yet cannot afford to ignore," Arne said in Washington alongside officials from the Organization for Economic Cooperation and Development. OECD presented the latest results from the Program for International Student Assessment (PISA), which measures how well students from more than 70 economies are prepared to meet the challenges they may encounter in the future.

Secretary Duncan provided this summary of U.S. students' performance on the 2009 PISA:

- In reading literacy, 15-year-old American students were average performers. The U.S. effectively showed no improvement in reading since 2000. Overall, the OECD's rankings have U.S. students in 14th place in reading literacy among OECD nations.
- In mathematics, U.S. 15-year-olds are below-average performers among OECD nations—ranked 25th. After a dip in our 2006 math scores, U.S. students returned to the same level of performance in 2009 as six years earlier, in 2003. U.S. students outperformed their peers in math in only five OECD countries.
- The most encouraging finding from PISA is that our average science score is up. In 2006, American 15-year-olds had below-average skills in scientific literacy, compared to their OECD peers. Today, U.S. students have improved enough to become average performers in science among OECD nations, earning 17th place in the OECD rankings.

"The hard truth," Secretary Duncan said at Tuesday's PISA announcement, "is that other high-performing nations have passed us by during the last two decades…In a highly competitive knowledge economy, maintaining the educational status quo means America's students are effectively losing ground."

PISA's high-scorers include South Korea, Finland and Singapore, Hong Kong and Shanghai in China, and Canada.

How much money the U.S. spends on education isn't the problem. We spend more per student than any nation in the PISA study except Luxembourg.

“The real problem with K-12 spending in the U.S. is our low educational productivity,” Arne said. “Unlike high-performing systems, we achieve less per dollar. And we do less to target spending on the most challenged students and schools.”

All but three nations in the OECD study—the U.S., Israel and Turkey—spend as much, or more, on those schools serving disadvantaged students as they do on those serving more privileged students.

A separate OECD study of the characteristics of the world’s top-performing education systems, along with a similar study of American and international practices by McKinsey & Company, suggests that the U.S. can improve our standing by continuing to pursue reforms that have taken root in states and local school districts within the last two years. High-scoring nations set rigorous standards for their students, smartly use data to improve instruction, concentrate resources on the most challenged students, and invest heavily in the teaching profession. Those successful nations’ practices closely mirror the priorities of the Obama administration’s Race to the Top program, OECD and McKinsey found.

“Our policies are moving us in the right direction,” Arne said. “Yet to lead the world again in achievement and college attainment, success must become the norm.”

To continue and deepen the conversation among nations’ education policymakers and educators, the U.S. Department of Education, OECD and other partners will convene an international summit on the teaching profession in New York in March, Arne announced today.

“The highest-performing and most rapidly improving countries have a great deal to learn from one another,” he said.

The announcement of America’s middling performance on PISA followed President Obama’s call Monday for rebuilding our nation’s economy on a new and stronger foundation. Education and innovation are critical, he said, declaring, “Our generation’s Sputnik moment is now.” In a generation, the United States has fallen from 1st place to 9th place in the proportion of young people with college degrees. The President has set a national goal of regaining 1st place by 2020.

International Education Rankings Suggest Reform Can Lift U.S./US Dept. of Education Blog
Posted on December 8, 2010 by jjohnson

Secretary Arne Duncan's Remarks at OECD's Release of the Program for International Student Assessment (PISA) 2009 Results
DECEMBER 7, 2010
ED.Gov

The following table shows Science Performance in 2000.

Country	Score
Korea, Republic of	552
Japan	550
Finland	538
United States Average Score for White Students	**535**
United Kingdom	532
Canada	529
New Zealand	528
Australia	528
Austria	519
Ireland	513
Sweden	512
Czech Republic	511
France	500
Norway	500
United States Average Score	**499**
Hungary	496
Iceland	496
Belgium	496
Switzerland	496
Spain	491
Germany	487
Poland	483
Denmark	481
Italy	478
Greece	461
Portugal	459
Luxembourg	443
United States Average Score for Hispanic Students	**438**
United States Average Score for African American Students	**435**
Mexico	422

Source: The Program for International Student Assessment (PISA) through OECD (Organization for Economic Cooperation and Development.

AVERAGE PISA SCIENCE LITERACY SCORES OF 15-YEAR OLD STUDENTS, BY COUNTRY, 2009

Country	Avg. Science Literacy Score	Country	Avg. Science Literacy Score
Shanghai-China	575	Slovak Republic	490
Finland	554	Italy	489
Hong Kong SAR	549	Spain	488
Singapore	542	Croatia	486
Japan	539	Luxembourg	484
Republic of Korea	538	Russian Federation	478
New Zealand	532	Greece	470
Canada	529	Dubai-UAE	466
Estonia	528	Israel	455
Australia	527	Turkey	454
Netherlands	522	Chile	447
Chinese Taipei	520	Serbia, Republic of	443
Germany	520	Bulgaria	439
Liechtenstein	520	Romania	428
Switzerland	517	Uruguay	427
United Kingdom	514	Thailand	425
Slovenia	512	Mexico	416
Macao-China	511	Jordan	415
Poland	508	Trinidad and Tobago	410
Ireland	508	Brazil	405
Belgium	507	Columbia	402
Hungary	503	Montenegro, Republic of	401
UNITED STATES	**502**	Argentina	401
Czech Republic	500	Tunisia	401
Norway	500	Kazakhstan	400
Denmark	499	Albania	391
France	498	Indonesia	383
Iceland	496	Qatar	379
Sweden	495	Panama	376
Austria	494	Azerbaijan	373
Latvia	494	Peru	369
Portugal	493	Kyrgyz Republic	330
Lithuania	491		

Source: The Program for International Student Assessment (PISA) through OECD (Organization for Economic Cooperation and Development.

Science Performance in 2009

The framework for the NAEP science assessment was updated in 2009 to reflect advances in science, curriculum standards, assessments, and research on science learning (NCES 2011). The new assessment placed a greater emphasis on what students can do with science knowledge.

Science Literacy Among U.S. 15-Year-Olds

U.S. students performed relatively better in the PISA science assessment. The average science literacy score of U.S. 15-year-olds improved by 3 points from 2006 to 2009. Whereas U.S. students scored lower than the OECD average in 2006 (489 versus 498), this gap was not evident in 2009 (502 versus 501).

The U.S. gains in science since 2006 were mainly driven by improvements at the bottom of the performance distribution; performance at the top remained unchanged. Despite improvement, the 2009 U.S. score (502) was below that of 12 OECD nations (512−554). For example, U.S. students scored lower than students in 5 top-performing OECD nations (Finland, Japan, Republic of Korea, New Zealand, and Canada) by 27−52 points. U.S. students also lagged behind their peers in (non-OECD) Shanghai-China, Hong Kong, and Singapore (by 40−73 points),

Relatively few students at grades 4, 8, and 12 reached their grade-specific proficiency levels in science on the 2009 NAEP assessment. Science scores varied significantly across student subgroups. At all three grade levels, whites, Asians/Pacific Islanders, and students from higher income families scored significantly higher than their counterparts. Boys also scored higher than girls at all three grade levels, but the difference was substantially smaller.

Results of international mathematics and science literacy tests show that U.S. 15-year-olds continue to lag behind their peers in many other countries, even though their scores have improved somewhat in recent years.

Efforts to improve student achievement include raising high school graduation requirements, strengthening the rigor of curriculum standards, increasing advanced course taking, promoting early participation in gatekeeper courses such as algebra I, and improving teaching quality.

From 1987 to 2008, the number of states requiring at least 3 years of mathematics and science courses for high school graduation increased from just a few states to more than 30. By the end of 2010, 44 states had adopted a common set of rigorous academic standards designed to ensure that students graduate from high school prepared for college and careers.

Trend data from 1990 to 2009 show an upward trend of students earning more mathematics and science credits and participating in advanced mathematics and science courses. Nevertheless, completion rates in some advanced courses remained relatively low, and wide gaps in advanced mathematics and science course taking persisted among racial/ethnic subgroups.

Indicators related to teaching quality show that virtually all mathematics and science teachers in public middle and high schools have such basic credentials as a bachelor's degree and teaching certificate, and proportionally more mathematics and science teachers had advanced degrees in 2007 than in 2003.

NCES 2011-004 U.S. DEPARTMENT OF EDUCATION
Highlights From PISA 2009: ***Performance of U.S. 15-Year-Old Students in Reading, Mathematics, and Science Literacy In An International Context***

Interesting Stats:

1. In 2009, the nationwide average science score of **eighth** grade public school students was 149. Average scores for individual states ranged from a high of 162 to low of 132. MO students had an average score of 157.
2. In 2009, 29% of eighth grade public school students nationwide performed at or above the proficient level in science. Among the states, there were significant differences in the percentage of eighth grade public school students who demonstrated proficiency in science. State values for this indicator ranged from 15% to 43%. In MO, 36% were proficient in science.
3. In Missouri, 13.4% of Missouri high school students were enrolled in AP classes in 2012 compared to 5.5% in 2000.

Missouri Mathematics and Science Coalition Fact Sheet

An Idea to Promote Science Education & Interest

"Imagine the lives of Jane and John 15 years after graduating from high school. Jane's daughter suffers from severe allergies, having tried various diets and medications. Her church building committee wonders how much to invest in energy efficiency. John's mother worries about the risks of hormone replacement therapy. His community's school board is deciding whether "intelligent design" should be taught in the classroom. Both Jane and John plan to vote in an upcoming election in which the candidates hold widely different views on climate change; the ballot also has referenda tightening regulations on smoking and alcohol consumption due to health concerns.

As Jane and John grapple with the issues affecting them, their families, and their communities, will their high school science educations help them make informed decisions?

Much of the National Science Education Standards, aside from the inquiry and teaching sections, focus on content. Our call is instead to build standards that focus on what students need to be scientifically literate in 10 or 15 years. Although a basic understanding of important scientific concepts and an understanding of how inquiry is practiced are immensely helpful, they are not enough.

Students need ways to find, evaluate, and make sense of new scientific and technical information that we cannot predict with any degree of certainty. Even in the present, students need skills that enable them to make decisions on technical issues and understand what takes place in cutting-edge laboratories and the papers generated directly from scientists' work. What standards and skills might support such understandings?"

Source: Science Journalism: Students Learn Lifelong Science Skills by Reporting the News by Joseph Polman, Alan Newman, Cathy Farrar, and E. Wendy Saul

Why is Public Science Education Important?

"For most Americans, science is something to be tolerated in high school, details of which are promptly forgotten after tests are over. This may be understandable, since, regrettably, the basic science curriculum can often consist of lectures on taxonomy or analogous facts about what science has discovered, along with the painful need to memorize long lists of strange words. But any notion that science should be left to the scientists, and that the very question of what is and is not science should be left to those with a political agenda, is wrong and damaging.

As the pace of scientific research accelerates, the average citizen is faced increasingly with having to grapple with matters of science in his everyday life. Some of the country's most complicated and urgent public policy debates have at their center been questions of science. It is imperative that the public is engaged in science issues which have an impact on their lives, in their own self-interest, to best thrive in modern society.

Furthermore, citizens must understand what is a question of science, and what is a question of public policy that can be informed *by* science. For example, the many causes and effects that impact human health are questions of science: smoking is a cause of lung cancer; obesity is a cause of diabetes; lead poisoning is a cause of brain damage in the young; alcohol and drug use by pregnant women are a cause of brain damage to their unborn children. These are objectively proven claims and therefore are science. The public must also grapple with important public policy questions that must be informed *by* science. For example, an understanding of the science of embryonic stem cell research is critically important to inform policymakers who are advocating or opposing this research; an understanding of climatology is essential to those concerned with regulation of fossil fuel consumption and energy policy; astronomy and cosmology must inform wise investment in space exploration.

On a less weighty level, science is everywhere in society; a part of each person's everyday life – even grocery shopping is more informed by a basic understanding of science. But most citizens are not equipped to personally assess the facts, nor often even to separate the facts from opinion or political spin; science from non-science. They therefore are likely to be predominantly influenced on these issues by the prevailing perception in their communities.

Yet no country, no matter how sophisticated technologically, can advance its society fully without the informed engagement of its citizenship. The existence of a democratic process (voting rights, a transparent and representative governance structure) is necessary but not sufficient. As with economic decision-making, public policy decision-making depends on full information. The nonscientist is increasingly at a disadvantage because he/she lacks the information to engage in these important public policy dilemmas as an informed, independent thinker.

How can we equip our people with sufficient scientific skills to enable them to develop informed opinions about these important issues, without imposing the unrealistic expectation that they be trained as scientists? This question is distinct from the question of how the U.S. can continue to produce the world's leading scientists. The latter consideration is also of course critical to the future health and economic prosperity of the Nation. But without a broad populace of "science appreciators", both the continued national investment in science and the implementation of enlightened public policy will be threatened."

Elizabeth Marincol, President, Science Service, Washington, D.C, January 24, 2006
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1395333/

Title: Preparing Youth For A Basic Understanding Of Science And Technology—
In The Scope Of Education: What Can Be Done?

As you can tell from the information provided, science education and where we rank in the world is a major problem in our country and concern for our government; in addition, research shows that students need to see the relevance of science in their lives at an early age. Not being able to compete in the global world in science and technology is definitely a problem for our communities, state, and country. Why has this happened? What can be done to remedy this problem? This Issue Paper is an invitation to discuss this problem and consider possible courses of action. The following are three (3) different approaches to talk through this problem and try to solve this very troublesome issue:

Approach One: Introduce Youth To Importance Of Science And Technology

What Can Be Done?

- Provide parents with information and strategies for introducing the concept of science at an early age.
- Make learning science and technology fun
- Encourage high school students to take advanced high school courses.
- Provide resources to help teachers get advanced science degrees.
- Provide incentives for science and technology teachers to teach in rural school districts.
- Ensure that youth and adults are aware and/or have access to science and technology museums and related field experiences.
- Create awareness campaign to make sure youth are aware of significance of science and technology in a global society

Trade-Offs

- Parents might see this more as the role of the school than the role of the parent
- With more emphasis on science and technology, other subject matters such as social studies or Communications Arts might suffer; there is only so much time in the school day
- If incentives are given to teachers to teach in rural areas, it might create shortage of qualified science & technology teachers in urban/suburban areas or create a shortage of teachers in other disciplines such as English, Social Studies, or Math
- With new incentives, will qualified teachers stay in rural and underserved schools?
- Will schools and communities have the resources necessary to test and measure student performance in Science & Technology?

What Critics Say

- Parents do not have the knowledge or skills necessary to motivate students to learn science
- School systems that provide computers and high quality science teachers & labs may neglect music and the arts
- Putting resources into science and technology won't ensure that students will perform better on tests
- Putting resources into S&T in rural schools might take resources away from urban schools

Approach Two: Partner With Businesses

What Can Be Done?

- Work with businesses to provide both paid and non-paid internships in science and technology fields at both the high school and college levels
- Encourage business to sponsor science and technology competitions for middle and high school students
- Provide scholarship opportunities high school students to pursue degrees in science and technology related fields
- Underwrite scholarships for teachers to pursue undergrad and graduate degrees in science and technology.

Trade Offs:

- If businesses provide internships in science & technology, they may not provide internships in other business related fields
- Businesses involvement in Science & Technology may mean a loss of sponsorships in other fields
- More interest by business in S & T might mean more foreign students will come to the U.S. to study

What Critics Say:

- Businesses providing S&T scholarships for high school students might be doing so for their own motives and not to really help the students
- With more students majoring in S&T, will the U.S. and world be able to generate enough jobs for all the graduates entering these fields?

Approach Three: Address the Root Causes

What Can Be Done?

- Work with school officials, parents and community leaders to change attitudes about science and technology.
- Work with policy makers to change graduation requirements regarding science credit hours to graduate

- Help citizens understand what is a question of science and what is a question of public policy that can be informed by science.
- Encourage schools to begin science and technology education beginning with pre-school.

Trade Offs:

- Making the fields of science and technology more attractive and subjects themselves less threatening might create a surplus of students majoring in these subjects
- With more understanding of science comes more expectations of what the public can do with this knowledge
- Starting S&T education during pre-school years will take away quality time from basic skills education such as reading and writing
- With unemployment high, more emphasis and resources in areas where the jobs are (S&T) might help lower the unemployment rates

What Critics Say:

- Addressing low performance of all U.S. students in science is a daunting and costly task. We should concentrate only on those students that show ability and have interest.
- There is no guarantee that with more money and emphasis in S & T that student scores will go up
- Competing on a global scale in S&T is a monumental undertaking and one the U.S. is not prepared to undertake as the emphasis is on business and making money
- We should worry less about test scores and concentrate more on helping young people see the relationship between proficiency in science and jobs available