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Research Brief

Science for All

Question:
What do the national data suggest about an appropriate high school science curriculum?

Summary of Findings:

In a Nutshell

Students need to be competent in science because of its impact on everyday decision-making, the rapid pace of change and the increasing interdependent global economy (Lawton, 2007; U.S. Department of Education, 2000; Lederman, 1998). According to the National Research Council, "Teachers of science should develop communities of science learners that reflect the intellectual rigor of scientific inquiry and the attitudes and social values conducive to science learning" (1996). The overarching goals of the National Science Teachers Association (NSTA) and the National Research Council (1996) are for every student to:

- be scientifically literate
- know and understand the natural world
- use appropriate scientific processes and principles in making decisions
- increase economic productivity.

NAEP results
According to the NAEP (National Assessment of Education Progress) the 2005 test results for 12th graders showed a decline from those taking the test in 2000. Those who took physics, chemistry and biology did better than those who took biology and chemistry, however, these two groups scored higher than students who had taken just biology or more general types of science courses.

So, what does it mean? There is a link between taking a greater number of science courses, courses in specific content areas, and proficiency on the NAEP.

Students who were proficient in science were predominantly Caucasian (86%), had taken at least one Advanced Placement science course (40%) and had at least one parent graduate from college (68%). Students who were below basic were more likely to be a student of color (24% African-American, 20% Hispanic). Only 35% of those students reported having a parent who graduated from college and only 17% had taken at least one Advanced Placement course (U.S. Department of Education, 2005).

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Physics First

Traditionally the entry science course in high school has been biology, followed by chemistry and then physics. According to Lederman (2003, 2002, 1998), a Nobel laureate in physics, and the American Association of Physics Teachers, physics is the foundation upon which all other sciences are built and provides a scaffold for higher levels of science. To support this, the *Physics First* program was developed and designed to teach physics in the ninth grade, chemistry in the tenth grade, biology in the 11th grade and AP and other more advanced science courses in the 11th and 12th grades. The premise is that the science program should be designed around a single organizing principle and that students should be introduced to the scientific process and explore real world issues. From this introductory physics class, the other sciences will relate back to and expand on the principles of physics. Some curricular examples provided by a U.S. Department of Education report (2000) include:

- Biology: cloning, genetic manipulation, use of DNA as evidence
- Health: drugs, biological and chemical warfare, effects of herbicides and pesticides on food, nutritional information
- Earth science: global warming, effects of events caused by nature (i.e. earthquakes, hurricanes, etc.)
- Physics: role of science in country's security (i.e. nuclear physics, weapons, GPS, satellite communication).

Program development considerations

Although there is insufficient data to support physics as a students' first high school science class (Pasero, 2003), the literature includes several recommendations for establishing a viable science program. They include:

- The program should be coordinated throughout the entire district and a curriculum mapping process should be used to determine what is and is not being taught so that an appropriate curriculum can be designed.
- Math and science teachers should work together to develop the program that should be consistent with standards across the grade levels.
- Communities of teachers that encourage, support and sustain one another should be in place to work with peers and provide on-going staff development.
- Courses should be taught by highly qualified teachers in well-equipped classrooms.
- Sufficient time to teach science should be allotted; the recommendation from NSTA is 300 minutes per week.
- The curriculum should be relevant to students' lives.
- The curriculum from each course should build upon each other.
- Appropriate and sufficient resources should be available to support the curriculum.
- There should be equitable opportunities for every student to access the curriculum.
- Students should take and use what they learn and apply it in new ways through hands-on activities, inquiry, research and other actively engaging methods. NASTA recommends at least 40% of the time allotted to doing hands-on work and inquiry

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- Diverse teaching strategies should be used to meet the variety of students' learning styles.
- Student work should focus on observing, gathering information, sorting, classifying, predicting, solving problems and testing concepts.
- Students should be expected to think critically and question their own work and that of others.

From: Durkin, n.d.; National Resource Council, 1996; National Science Teachers Association; U.S. Department of Education, 2002

Resources:

- American Association of Physics Teachers (n.d.) *AAPT statement on physics first*. This is a statement on the physics first program and its goals. http://www.aapt.org/Policy/physicsfirst.cfm

- Durkin, B. (n.d.) *Block scheduling: Structuring time to achieve national standards in mathematics and science*. ERIC Digest. This article looks briefly at the need to restructure math and science courses in order to best meet the national standards set forth by the National Council of Teachers of Mathematics and National Science Teachers Association. http://www.ericdigests.org/2000-1/block.html

- East Bay Educational Collaborative. (n.d.). *Physics first Rhode Island high school reform initiative*. A newsletter from Rhode Island on physics education in the district is provided. Includes teacher resource guide. http://www.ebecri.org/custom/PhysicsFirst.html

- EDC. (2006) *Curriculum uses real life stories to introduce the disciplines, inspire students.* Reasons for restructuring the high school science program are briefly described in this article. http://main.edc.org/NewsRoom/features/foundation.asp

- Giovine, A. (2003). *Physics First for ninth-graders is goal of educators at CU conference.* A brief description of advantages to offering physics first in the high school curriculum is provided in this article. http://www.news.cornell.edu/chronicle/03/7.24.03/Physics_First.html

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- Hoff, D. J. (2000). *It's not your father's physics class*. From *Education Week*, this article explains some of the reasons for physics to be offered in the ninth grade are given in this article.
  http://www.its-about-time.com/htmls/ap/educationweek.html

- IES (2005). *The nation's report card: Science*.
  This is a brief description of the results of the NAEP science test from 2005 with active links to the full report.
  http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2006466

- Lederman, L. M. (2002). *ARISE: American renaissance in science education. Implementation Book*. Fermi National Accelerator Laboratory: Batavia, Il.
  "This report, which summarizes discussions from three workshops held in December 2001 and March 2002, contains reflections and suggestions on experiences, successes, concerns, and needs that teachers have encountered as they introduce and sustain a new science curriculum. Teachers have taken one of two approaches, "physics first" or integrated science."
  http://lss.fnal.gov/archive/2002/pub/Pub-02-088.pdf

- Lederman, L. M. (1998). *ARISE: American renaissance in science education*. Fermi National Accelerator Laboratory: Batavia, Il.
  This is a report on reasons why the traditional structure of science programs, initially designed in the late 1800s, needs to be revamped.
  http://lss.fnal.gov/archive/1998/tm/TM-2051.pdf

- National Research Council (1996). *National science education standards*. Washington, DC: National Academy Press.
  This is the home site that has active links to information on the national science education standards.
  http://www.nap.edu/readingroom/books/nses/

- National Science Teachers Association. *Official positions*.
  From this site, the reader can access the official positions of this organization.
  http://www.nsta.org/about/positions.aspx

- Pattanayak, V. (2003). *Physics First in science education reform*.
  This is a report on the results of the physics first program.
  http://www.jyi.org/volumes/volume6/issue7/features/pattanayak.html

- Pasero, S. (2003). *The state of physics-first programs*. Fermi Lab Education Office.
  This describes the program and issues of the physics-first program, however, one down side is that the participating schools collected little hard data about the results of the program.

http://lss.fnal.gov/archive/2001/pub/Pub-01-206.pdf

- U.S. Department of Education (2005). *The nation's report card: Science.*
  The results of the NAEP science test from 2005 are reported in this document. Sample test questions are included.
  http://nces.ed.gov/nationsreportcard/pdf/main2005/2006466_2.pdf

- U.S. Department of Education (2000). *Before it's too late: A report to the nation from the National Commission on mathematics and science teaching for the 21st century*.
  "The primary message of this report holds that America's students must improve their performance in mathematics and science if they are to succeed in today's world and if the United States is to stay competitive in an integrated global economy. The Report's second message points in the direction of a solution: the most direct route to improving mathematics and science achievement for all students is better mathematics and science teaching."
  http://www.ed.gov/inits/Math/glenn/toolate-execsum.html

State and Local Curriculum Maps

- Kentucky State Department of Education
  Curriculum maps for high school science
  http://www.kde.state.ky.us/KDE/Instructional+Resources/Curriculum+Documents+and+Resources/Teaching+Tools/Curriculum+Maps/High+School+Science+Curriculum+Maps.htm

- New Albany Plain Local School District (OH). (2006). *High school science curriculum work.*
  Curriculum maps of this district's high school science programs are provided on this site.
  http://www.new-albany.k12.oh.us/admin/curric/curric_work/9-12/science/HighSchoolScienceCurriculumWork.php

Examples of School Science Programs

- Box Elder High School, UT
  http://www.behs.besd.net/courseofferings/08-09_Course_Offerings.pdf

- Dwight-Englewood School, NJ
  http://www.d-e.org/s/589/images/editor_documents/content/Download%20the%202006-07%20Student%20Handbook%20here%20(PDF%20473%20KB)%20To%20h/student%20handbook.pdf

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- Piedmont High School, CA
  http://www.piedmont.k12.ca.us/phs/counseling/progguide.pdf

- Physics first member schools
  These are active links to schools that require physics as the entry science class.
  http://members.aol.com/physicsfirst/SchoolsbyState.html

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