Programs

Education

A long-term AAAS initiative to advanc in Science, Mathematics, and Tech

What's New

Updated 5 Apr 2006

Helping Students Make Sense of Heredity

NARST

National Association for Research in Science Teaching

In a paper presented at the annual meeting of the Nation Association of Research in Science Teaching (NARST), P 2061 staff describe how maps in *Atlas of Science Literac* provide useful models of learning progressions for heredi other key topics in the K-12 science curriculum. For more read the full paper.

Project 2061 Presentations at the NSTA Annual Conferenc Anaheim

NSTA

Are You Planning to Attend the N Annual Conference? If so, you m interested to learn Project 2061 presentations on its work relatin next volume of *Atlas of Science* and on the development of standards-based assessment More details.

New Guide for Teaching Evolution

Project 2061 introduced a guide to key evolution concepts at the AAA

Dialogue on Early Childhood Science, Mathematics, and Technology Education

Perspectives

Early Childhood Education in Science, Mathematics, and Technology: An NSTA Perspective

Fred Johnson

The National Science Teachers Association (NSTA) believes two issues must be considered regarding early childhood education. First, we must understand how and why young children learn. Second, we must identify programs and learning experiences that apply this understanding of early childhood learning to effectively meet young children's needs.

Current research on brain development emphasizes the importance of early stimulation in developing brain connections from birth. The Carnegie Task Force on Meeting the Needs of Young Children in 1994 issued a call for help in preparing children for learning when they enter school. This report states that "brain development is much more vulnerable to environmental influence than previously suspected and early environmental influence on brain development is long lasting." Neurobiology research regarding normal brain function is revealing more about how children learn (Markezich 1996).

"Learning windows"—optimal times for learning at particular developmental stages—should be used to enhance understanding of science, mathematics, and technology in young children. Research findings have strong implications for developing effective early childhood education programs because "rich experiences produce rich brains" (Nash 1997).

Piaget's theory of cognitive development was created in the 1920s, long before access to medical imaging technology and current brain research was available. The current national redirection of science and math teaching is grounded in this theory, which stresses the use of a teaching/learning cycle and explorations through the manipulation of objects and materials. "Developmentally appropriate practice"—a curriculum based on what is known about young children—should drive instruction (Clark 1996).

Research on children's motivation to learn and their underachievement reveals that young children are full of curiosity and a passion for learning (Raffini 1993). If this passion changes from delight to drudgery, one in four of those students will leave school before graduating. A greater understanding of student motivation is needed, particularly as it relates to intrinsic and extrinsic rewards for learning.

Documentation and evaluation data on Head Start, Title I, and the Military Child Care System may reveal models for effective preschool education. Closing the developmental gap between preschool children who are mentally stimulated by their family and surroundings and those who are not stimulated should be a priority in preparing children for school. The importance of brain development and the opportunities for early childhood stimulation calls for well-designed preschool education for three-, four-, and five-year-olds. These programs may compensate for a child's lack of stimulation in the previous years and months; they may also enhance less than stimulating home environments.

Cultural diversity and children with special needs are a particular challenge for early childhood education as developmental milestones are attained on a different schedule and in a different manner. If all children are to reach their potential, they must all be included in our concerns when we design and provide high-quality preschool educational opportunities.

Financing issues are always a concern. Local educational programming that is funded by grants and that receives special community support seems to be most effective: The stakeholders have more invested in the success of these programs. Educators' top priority should be financial assistance for preschool programs that are working effectively to prepare students for learning.

As NSTA considers neurological research and its implications for preschool education, we recognize the need for making the most of these early childhood years through well-designed preschool programs that provide science, mathematics, and technology education.

References

Clark, J. V. (1996). *Redirecting science education.* Corwin Press, Inc.

Markezich, A. (1996). *Learning windows and the child's brain.* Super Kids Educational Software Review. Knowledge Share LLC.

Nash, M. J. (1997). Fertile minds. *Time*, 149:5.

Raffini, J. P. (1993). *Winners without losers: Structures and strategies for increasing student motivation to learn.* Upper Saddle River, NJ: Prentice Hall.

Fred Johnson served as president of the National Science Teachers Association from June 1997 through June 1998.

Programs

Education

Learning Goals

Lasting science education reform must begin with learning goals. Learning goa development of curriculum materials, research and testing, and materials for fa communities. Clear and specific learning goals, along with time, resources, coll leadership are necessary for science literacy. The nationally recognized standa represented in *Benchmarks for Science Literacy* and published by Project 206' influenced state and local science, mathematics, and technology standards for

In this section, you will find a collection of material on the subject of Learning G among them is *Benchmarks On-Line*, an electronic version of the *Benchmarks Literacy*. In addition, there are press releases and newspaper, magazine and r articles, as well as other resources relevant to Learning Goals.

Resources

Atlas of Science Literacy
Atlas of Science Literacy is a collection of 49 conceptual strand maps that shov students' understanding of the ideas and skills that lead to literacy in science, r and technology might grow over time. Each map depicts how K–12 learning go particular topic relate to each other and progress from one grade level to the ne

Benchmarks for Science Literacy
Benchmarks for Science Literacy is the Project 2061 statement of what all stud know and be able to do in science, mathematics, and technology by the end of and 12. The recommendations at each grade level suggest reasonable progres adult science literacy goals laid out in the project's 1989 report *Science for All A*

Science for All Americans
Science for All Americans defines science literacy and lays out some principles learning and teaching. In coherent prose, it articulates and connects fundamen science without technical vocabulary and dense detail.

Articles

Creating Benchmarks For Science Education

Project 2061 has been constructing goals for science, mathematics, and techn education since 1985. The benchmarks are to be used by school districts or cu developers in constructing alternative K- 12 curriculum models adapted to their populations and circumstances.

Lessons from Project 2061: Practical ways to implement benchmarks and stan The science books used in the classroom today provide a lot of facts, but they children grasp the most basic concepts about the world we live in.

Press Releases

New Tool Mapping the Growth of K–12 Science Understanding Released by A 2061 and NSTA
(2001-01-22) In a first-ever joint publishing arrangement, Project 2061 and the Na Teachers Association (NSTA) provide educators with an innovative tool that gr depicts connections among key learning goals for students in kindergarten thro grade.

Remarks on the Release of the NAEP 2000 Science Assessment Results
(2001-11-20) Dr. George Nelson remarks on the release of the 2000 National Ass Educational Progress. The results show students are lagging in science educat been no significant improvement in average scores or achievement levels over years.

Elsewhere on the Web

NCTM Principles and Standards for School Mathematics
Principles and Standards represents a continuing effort by National Council of Mathematics (NCTM) to support mathematics teachers and ensure that every s receives a high-quality mathematics education. The document delineates six P set forth important characteristics of Mathematics programs and ten Standards the mathematics students need to be able to know and do across the grades.

TOP OF PAGE » HOME « PRESS POLICY EDUCATORS STUDEN

Programs

Education

Curriculum Materials

Curriculum materials are a critical component of improving science and mather education, yet many materials fail to teach the most important concepts in an e Consequently, Project 2061 is working to improve materials and help educator developers, and publishers identify and create instructional materials that can h students achieve literacy in science and mathematics.

In this section, you can access a variety of curriculum-related resources, includ on Project 2061's research efforts, a list of relevant articles, and Project 2061's some of the most widely used middle- and high-school science and mathemati You can also learn how a Project 2061 partnership with three universities as pa Center for Curriculum Materials in Science will guide curriculum material resea development and improve science instruction.

Key Initiatives

Center for Curriculum Materials in Science
The Center for Curriculum Materials in Science (CCMS) is a partnership of AA State University, Northwestern University, and the University of Michigan. It is f analysis, design, and use of science curriculum materials.

Improving Learning in Middle Grade Mathematics
Through a jointly funded program, and in partnership with two universities, Proj investigating how best to coordinate teaching practices, curriculum materials, a professional development to improve student learning in Middle Grades mathe

Resources

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and 12. The recommendations at each grade level suggest reasonable progres
adult science literacy goals laid out in the project's 1989 report *Science for All*

Evaluation of Science and Mathematics Textbooks
Project 2061 began its series of textbook evaluations with an analysis of middle
mathematics texts, released in January 1999. Additional evaluations have cove
grades science, algebra, and high school biology.

AAAS Science Textbook Conference CD-ROM Resource
Conference attendees used this CD-ROM to delve into the criteria and the rele
base for Project 2061's textbook evaluation studies. The CD-ROM contains eva
on three stand-alone science units developed by Michigan State University and
Department of Education.

Articles

Helping Students Make Sense of Heredity
In a paper presented at the 2006 annual meeting of the National Association of
Science Teaching (NARST), Project 2061 staff describe how maps in *Atlas of S*
Literacy can provide useful models of learning progressions for heredity and ot
in the K-12 science curriculum. For more details, read the full paper titled Mapp
Learning Progression for the Molecular Basis of Heredity.

Errant Texts: Why some schools may not want to go by the book
In 2000, the National Center for Education Statistics unveiled a series of disqui
from an international study of students' math and science achievement. The da
among 38 surveyed nations, eighth graders in the United States ranked no bett
middle of the pack. Many school administrators and especially scientists are co
conclusion that one major problem resides in the textbooks U.S. middle school

The Trouble With Textbooks
The science books used in the classroom today provide a lot of facts, but they
children grasp the most basic concepts about the world we live in.

Press Releases

Transforming Textbooks: AAAS and Partners Target K-12 Science Materials fo
(2002-10-22) Transforming K-12 science textbooks—which so often cause studer
parental criticism, and teacher migraines—will be the focus of a new Center for
Materials in Science, announced today by the American Association for the Ad
Science (AAAS) and its education reform initiative, Project 2061.

Project 2061 Staff Receive Distinguished Article Award
(2003-03-25) The National Association for Research in Science Teaching (NARS
two Project 2061 staff members with NARST's 2003 Distinguished Paper Awar
which describes in depth how Project 2061 conducted its landmark study of mi
science textbooks to evaluate how likely they are to support the teaching and le
science ideas.

Elsewhere on the Web

Partnership for Science Literacy
Your children need a great science education and you can do a lot to help mak
The first place to start is right here, where you'll find a world of information, acti
ideas that are just like science - exciting, useful, and offering something for the

Center for Curriculum Materials in Science
The Center for Curriculum Materials in Science (CCMS) is a collaboration of Pr
the American Association for the Advancement of Science (AAAS), Michigan S

Northwestern University, and the University of Michigan. It is focused on the ar
and use of science curriculum materials and the development of new leaders ir
education. Funded through the National Science Foundation's Centers for Lear
Teaching program, CCMS is helping to enrich the national infrastructure for sta
K-12 science, mathematics, and technology education.

TOP OF PAGE ▲ HOME ◀ PRESS POLICY EDUCATORS STUDEN

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Programs

Education

Testing & Assessment

Assessment of academic performance is a major influence on the lives of child every level of the educational system. Aligning tests with the specific ideas and expect students to learn is vital, but what does alignment really mean? With su National Science Foundation (NSF), Project 2061 is developing strategies and evaluating the alignment of K–12 assessments in science and mathematics wit state standards and benchmarks.

Linking Science and Mathematics Assessments to Standards
In a five-year NSF-funded effort, Project 2061 is using its experience in analyzi to develop a collection of high-quality middle- and early high-school science an assessment items, including multiple choice and open-response questions. The bank of items will be accessible online and linked to state and national science standards. Read the proposal to learn more.

In developing science assessment items for its online collection, Project 2061 r first clarify and elaborate the relevant content standards and identify the key id are intended to learn. As items are developed to target the key ideas, the resea set of alignment criteria to guide their work. They also use research on student design distractors to diagnose student misconceptions. Eventually, they try out students to gather more information on how students think through their answe Feedback from the students is used to revise the items.

The following articles provide additional information on this project:

- Getting Assessment Right: Rigorous Criteria, Student Data Inform Proje Assessment Design (*2061 Today*, Winter 2007) [PDF]
- Student Feedback Takes Center Stage (*2061 Connections*, January/Fe
- Learning from the Students: Interviews Bring Student Feedback into As Development (*2061 Today*, Fall 2005) [PDF]
- Work Begins on New NAEP Science Framework (*2061 Today*, Spring 2
- Assessment with Precision: Project 2061 Building a Collection of Test It Standards (*2061 Today*, Summer/Fall 2004) [PDF]
- Building a Collection of Test Items Aligned to Standards (*2061 Connect* 2004)
- High-Quality Assessment Items on the Horizon (*2061 Connections*, Ma

Do You Have Assessment Items Linked to Science Learning Goals?
Project 2061 is seeking test items that are aligned with learning goals selected *Benchmarks for Science Literacy* and *National Science Education Standards*. I contribute!

Project 2061's Approach to Assessment Alignment
With funding from the NSF, Project 2061 has developed an assessment analys determine the alignment of K–12 science and mathematics assessment items t state standards. Using the innovative procedure, educators can establish what learning goals an assessment task targets and then judge the likely effectivene in probing student achievement of those goals. Some of the questions asked ir are:

- Is the exact knowledge specified in the standard(s) needed to make a s response?
- Is the exact knowledge specified in the standard(s) enough by itself to n satisfactory response or is additional knowledge needed?
- Are students likely to comprehend the task?
- Are students likely to understand what they are expected to do and wha response is considered satisfactory?
- Is the task's context appropriate?
- Could students respond satisfactorily to the task by guessing or employ general test-taking strategies?
- Is the task's scoring guide adequate and accurate?

Project 2061's assessment analysis procedure is currently being used by deve instructional and assessment materials; by districts and states that create, sele administer large-scale testing programs; and by classroom teachers who creat tests. View a prototype version of Project 2061's assessment analysis utility.

The following articles provide additional information on the analysis procedure:

- Aligning Assessment to Content Standards: Applying the Project 2061 A Procedure to Assessment Items in School Mathematics (A presentation AERA annual meeting in Montreal, Canada, on April 12, 2005)
- Aligning Student Assessment to State and National Content Standards given at the NSTA national convention in Dallas, TX, on April 1, 2005)
- Accountability and Assessments (*RBS Currents*, Fall/Winter 2002)
- Aligning Assessment with Learning Goals (*ENC Focus*, 2000, Volume 7

Related Project 2061 Tools

- *Blueprints for Reform*
- *Dialogue on Early Childhood Science, Mathematics, and Technology E*
- All Project 2061 publications

Elsewhere on the Web

- Links to Related Education Web Sites
- National Center for Education Statistics

TOP OF PAGE ▲ HOME ◀ PRESS POLICY EDUCATORS STUDEN

Programs

Education

Teaching & Learning

High quality research is a fundamental first step in finding out how today's stud able to learn science, mathematics, and technology and how instructional, curr assessment strategies and materials can best support their learning. Project 2(applying the available research on student learning to guide its development of learning goals in *Benchmarks for Science Literacy* (1993). Research also provi for Project 2061's criteria for evaluating the effectiveness of science and mathe textbooks and the alignment of assessment items with benchmarks and standa

Project 2061 is now leading two major research efforts that will contribute signi understanding of science and mathematics teaching and learning. With a $5.8 from the Interagency Education Research Initiative (IERI), Project 2061—in pa the University of Delaware and Texas A&M University—is studying how to prov scale, the professional development and continuing support teachers need to i learning of key ideas and skills in middle-grades mathematics.

And through the National Science Foundation's Centers for Learning and Teac Project 2061 has received a $9.9 million five-year grant to establish a Center fc Materials in Science, working in collaboration with Michigan State University, N University, and the University of Michigan. In addition to developing new gradu postdoctoral programs in curriculum materials development, the new Center wi pioneering research on the design and use of effective curriculum materials for learning.

Paper Presented at AERA Annual Meeting

A paper was presented at the annual meeting of the American Educatic Research Association (AERA) April 12-16, 2004, in San Diego, Californ a focus on a five-year Interagency Education Research Initiative study t explores the interactions of curriculum materials and professional devel and their effect on teachers' classroom practices and on students' achie in mathematics. You can access the paper here.

Key Initiatives

Center for Curriculum Materials in Science
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Science for All Americans
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Dialogue on Early Childhood Science, Mathematics, and Technology Educatio
Dialogue on Early Childhood Science, Mathematics, and Technology Educatio some of the latest thinking about early childhood science, mathematics, and te education. It brings together 11 papers on wide-ranging topics commissioned b American Association for the Advancement of Science (AAAS).

Resources for Science Literacy: Professional Development
This is Project 2061's first CD-ROM tool and the first professional development to focus on standards-based teaching and learning. *Resources* offers a wide a materials designed to provide educators with a deeper understanding of how tc students achieve science literacy.

Articles

Less Is More: Trimming the Overstuffed Curriculum
Through a science curriculum "diet," districts discover that less topics could fat understanding. Instead of forcing students to digest more and more content an as science continues to advance, experts recommend a science curriculum "di a bite out of the nation's current science achievement woes.

Solving the Equation: Project 2061 Studies Factors That Improve Student Lear Mathematics
Project 2061's evaluation of middle-grades mathematics textbooks indicates th materials have high potential for improving student learning, but empirical stud show how these materials—and professional development related to these ma actually support effective teaching practices and improve student learning.

Meetings & Conferences

Technology Education Research Conference
Participants from science education, technology education, and cognitive scien in December 1999 to discuss the role of research in technology education. Tec discussed from a wide range of perspectives, including its relationship with scie society, the notion of design, control mechanisms, materials, energy, and comr

April 2001 a second technology conference was held to build on the high-priori issues identified in the first conference.

AAAS Conference on Improving Science Textbooks through Research and De

Policy & Student Learning: What Textbooks, Assessment, and Professional De Can Contribute

In our continuing effort to significantly improve student learning in science, mat technology, Project 2061 of the American Association for the Advancement of S a conference that focused on state and district policies that influence student le conference, the third in a series of Project 2061 conferences dedicated to impr textbooks and curriculum, examined policies that affect the quality of materials instruct and assess students and the professional development available to tea

Press Releases

Project 2061 Staff Receive Distinguished Article Award

(2003-03-25) The National Association for Research in Science Teaching (NARS two Project 2061 staff members with NARST's 2003 Distinguished Paper Awar which describes in depth how Project 2061 conducted its landmark study of mi science textbooks to evaluate how likely they are to support the teaching and le science ideas.

Elsewhere on the Web

TOP OF PAGE ▲ HOME ◀ PRESS POLICY EDUCATORS STUDEN

Programs

Education

Family & Community

Family and communities that are committed to excellence are indispensable fo of science, mathematics, and technology education reform and for achieving sc for everyone. Parents recognize that a high-quality science education can prov children with skills that are useful for life, and this section presents resources tc their role of preparing their children for life.

International studies show that the United States continues to lag behind other students' knowledge of science and math on virtually every measure available. that many students are not being prepared for a world that is shaped by scienc technology. And for our society to remain competitive in an advanced technolo good science education is critical, regardless of what a child's eventual course be.

The good news is that for most children, science continues to be a source of fa parents can play an active role in tapping into that curiosity and contributing to Project 2061 has put together resources to help parents and families ensure th receive the good science education they deserve.

The American Association for the Advancement of Science (AAAS) founded Pr 1985 to help all Americans become literate in science, mathematics, and techn 1989 landmark publication *Science for All Americans*, Project 2061 set out rec for what all students should know and be able to do in science, mathematics, a by the time they graduate from high school. *Benchmarks for Science Literacy*, 1993, translated the science literacy goals in *Science for All Americans* into lea benchmarks for grades K-12. Many of today's state and national standards doc drawn their content from *Benchmarks*.

More recently, AAAS has launched a public awareness initiative on science ed special science news website for kids. The Partnership for Science Literacy, fu National Science Foundation, is a national effort aimed at empowering families their children's science education, while the *Science* News Page for Kids provi informative articles for children from the renowned scientific journal.

The resources in this section can help you understand more about the critical i surrounding science education and what you, as parents, can do to help.

Key Initiatives

Partnership for Science Literacy

Resources

Family Guide to Science
Click here to order your free copy of this guide which provides useful informatic science activities for parents and families everywhere. In addition to the nationa there are five community-specific editions of the guides to help you find out abc resources - including science centers and museums, nature centers and botan zoos, aquariums, local parks, science organizations, schools, and more - in Au Lehigh Valley, Los Angeles, and Tampa.

The Partnership for Science Literacy - Science is Everywhere!
Your children need a great science education and you can do a lot to help mak The first place to start is with this website, where you'll find a world of informati and ideas that are just like science - exciting, useful, and offering something fo family!

Science News Page for Kids
Check this site regularly for new news features on science issues that your chil understand and enjoy! This site, launched in June 2003, is presented by AAAS and is hosted on EurekAlert!, the AAAS science news Web site.

ParentsInvolved.org Educational Research Topics
This special site from the Education and Human Resources Directorate of AAA links to information about educational research topics of interest to parents anc

AAAS Education and Human Resources: Children, Family and Communities p
This special site from the Education and Human Resources Directorate of AAA information on the research and educational programs for students at the K-12 levels.

Articles

Is Your Child's Science Education What It Should Be?
Ten Questions to Ask Your Local School
Scientists and educators with Project 2061, a long-term reform initiative to impr mathematics, and technology education, worry that today's students aren't beir well enough to live in tomorrow's science-oriented world. That is why Project 2(created a set of ten questions parents can ask their local schools to help them whether their child is gaining the knowledge and skills they will need as adults i century.

You don't Have To Be A Rocket Scientist To Think Like One
We don't necessarily need more rocket scientists. But we do need leaders and can think like scientists and schools that can produce them. Scientific thinking s used to improve the chances of success in virtually any endeavor, from buildin performing heart surgery to managing a business or designing a school curricu

Press Releases

AAAS's Project 2061 to Build Public Support for Science Literacy in Four-Year Campaign
(2001-10-01) Recognizing that parents and community leaders can make or breal science and mathematics education, Project 2061, announced a new effort to c an effective public outreach campaign. A recently awarded grant of $5.9 millior National Science Foundation (NSF) will support both the public outreach camp concurrent effort by Project 2061 to develop new tools for teachers, curriculum

and textbook authors and publishers.

Spanish Version of Project 2061 Information Advances Goal of Science Literac (2000-03-14) The Project 2061 information is fully searchable and features the co Spanish editions of two of the project's most influential publications, *Science fo* (1989) and *Benchmarks for Science Literacy* (1993). Both books have been wi by the Ministry of Education in Mexico.

Elsewhere on the Web

TryScience
TryScience.org is your gateway to experience the excitement of contemporary technology through on and offline interactivity with science and technology cen TryScience is brought to you through a partnership between IBM Corporation, Hall of Science (NYHOS), the Association of Science-Technology Centers (AS science centers worldwide

TOP OF PAGE ▲ HOME ◀ PRESS POLICY EDUCATORS STUDEN

Programs

Education

Source:
Educational Leadership, October 1999 - Volume 57 - Number 2

Science Literacy for All in the 21st Century

As the roles of science, mathematics, and technology gro society, the corresponding school curriculums must empl depth of knowledge, not breadth of information.

George D. Nelson

In general knowledge of science and mathematics, U.S. 12th graders were am scoring students from the 41 nations that participated in the Third International and Science Study (TIMSS). And US students taking advanced placement mat physics courses ranked even lower when compared with their non-U.S. counte TIMSS study is compelling evidence of what we have known for decades: Mos even the brightest, are failing to learn much that is useful in science, mathemat technology (Schmidt, McKnight, & Raizen, 1997). These symptoms point to a c condition that ultimately threatens the health and well-being of both our nation

The Need for a Science-Literate Population

As the world becomes increasingly scientific and technological, our future grow dependent on how wisely humans use science and technology. And that, in tur the effectiveness of the education we receive. With the exploding impact of sci technology on every aspect of our lives, especially on personal and political de sustain our economy and democracy, we cannot afford an illiterate society.

For our species to thrive in the next century, we must, through deliberate educ universally literate society. And the definition of literacy must expand to include reading and arithmetic, but also science, mathematics, and technology. The life potential of science and technology cannot be realized unless everyone unders nature of these subjects and acquires basic scientific habits of mind. Without a literate population, the outlook for a better world is not promising.

Our Current Condition

So, how are we doing? Not well, I'm afraid, especially in science, mathematics, technology. A classic video made at a Harvard University graduation illustrates (Private Universe Project, 1989). In the video, young graduates and faculty--sti and gowns-- answer this question: Why is it warm in the summer and cold in th Twenty-two out of 25 got the answer wrong. The typical answer was that it's wa summer because the earth is closer to the sun. (The correct answer is that it's because the tilt of the earth, which remains constant as the earth orbits the sur hemisphere at an angle to receive maximum sunlight during the summer. The the earth to the sun varies very little--actually, the earth is a little closer to the s

More than half of the US population doesn't know that the earth orbits the sun scientists figured out that it does. Almost no one can explain what the phrase " even means. Worse still, few can distinguish between an evidence-based expla the physical world works and an opinion-based one.

The science-literate population is a tiny minority. Not until the few upper-divisio students majoring in science or engineering begin taking serious science and n courses do they face learning the ideas, concepts, and habits that are so impor Unfortunately, this leaves out most people--including most future science and r teachers.

Those of us in education must take most (if not all) of the blame for our nation's in science literacy. We've become burdened by the overwhelming amount of ne and the perceived need to lay it all out. Over the last 50 years, K-12 science, m and technology curriculums have become ever-expanding accumulations of fac and hollow activities. As long as some students can absorb and emit this inform without much mental processing--we call it "learning." But what should students How should students be taught? How can we improve science and mathematic

In Pursuit of Science Literacy

In 1985, the American Association for the Advancement of Science (AAAS) lau term effort to reform science, mathematics, and technology education. With Ha view that same year, the project's originators considered all the scientific and te changes that a child entering school in 1985 would witness before the return of 2061. They chose the name Project 2061 to suggest that meaningful reforms to depend on a long-term vision of the knowledge and skills that today's students adults in the 21st century.

With expert panels of scientists, mathematicians, and technologists, Project 20 identify what was most important for the next generation to know and be able to would make them science literate. In two major reports, *Science for All America* 1990) and *Benchmarks for Science Literacy* (AAAS, 1993), Project 2061 descr knowledge and recommends learning goals for elementary, middle, and high s as they progress toward science literacy.

Guidelines for Reform

Science for All Americans and *Benchmarks* are based on the premise that the person is aware that science, mathematics, and technology are interdependent enterprises with strengths and limitations; understands key concepts and princi science; is familiar with the natural world and recognizes both its diversity and scientific knowledge and scientific ways of thinking for individual and social pur 2061 helped establish science literacy as an important national goal for all stud captured and influenced the growing national consensus on what constitutes s and suggested guidelines for successful reform.

In a joint statement issued in February 1996, AAAS, the National Academy of S

the National Science Teachers Association affirmed their commitment to scien

- The first priority of science education is basic science literacy for all stuc those in groups that have traditionally been poorly served by science ec
- Education for universal science literacy will, in addition to enriching ever create a larger and more diverse pool of students who are able and mot pursue further education in scientific fields.
- Science literacy consists of a knowledge of certain important scientific fa and theories; the exercise of scientific habits of mind; and an understan nature of science, its connections to mathematics and technology, its im individuals, and its role in society.
- For students to have the time needed to acquire the essential knowledg science literacy, the sheer amount of material that today's science curric cover must be significantly reduced.
- Effective education for science literacy requires that every student be fre actively involved in exploring nature in ways that resemble how scientist

But many obstacles lie on the way toward science literacy for all. The nation's c textbooks, and teaching continue to lack focus and to emphasize quantity over data from TIMSS indicate, the nation's approach to science and mathematics e mile wide and an inch deep."

Improving the Science Curriculum

Today's science textbooks and methods of instruction, far from helping, often a progress toward science literacy. They emphasize the learning of answers mor exploration of questions, memory at the expense of critical thought, bits and pie information instead of understandings in context, recitation over argument, reac than doing. They fail to encourage students to work together, to share ideas an freely with one another, or to use modern instruments to extend their intellectua

Today's science and mathematics curriculums are overstuffed and undernouris time, they have grown with little restraint, overwhelming teachers and students difficult to keep track of what science, mathematics, and technology are truly es topics are taught over and over in needless detail; some that are of equal or gr importance to science literacy--often from the physical and social sciences and technology--are absent or are reserved for only a few students.

Benchmarks for Science Literacy challenges the status quo in science educatic a coherent set of specific learning goals, or benchmarks, for grades K-2, 3-5, 6 The recommendations at each grade level suggest reasonable progress towar science-literacy goals laid out in *Science for All Americans. Benchmarks* can h decide what to include in or exclude from a core curriculum, when to teach it, a sequence of benchmarks for a given topic reflects a logical progression of idea grade benchmarks anticipating the more advanced benchmarks for later grade

Benchmarks has had a significant impact on the reform movement. Its recomm have helped shape the national science education standards and have given e every state and school district a powerful tool for fashioning their own local curr

A New Approach to Teaching

Project 2061's work has also brought attention to the growing body of research nature of learning and teaching when science literacy is the goal. Consider the *Science for All Americans,* for example, that "learning is not necessarily an outc teaching." Cognitive research reveals that even with good instruction, many stu including academically talented ones--understand less than we think that they example, although students taking an examination may be able to identify what been told or what they have read, careful probing by teachers often shows that understanding is limited or distorted, if not altogether wrong. This finding sugge parsimony is essential in setting out educational goals: Schools should pick an the most important concepts and skills so that they can concentrate on the qua

understanding rather than on the quantity of information presented.

In a classroom where science literacy is the goal, *teaching should take its time.* science, students need time for exploring, making observations, taking wrong t ideas, and doing things over; time for building things, calibrating instruments, c things, and constructing physical and mathematical models for testing ideas; tir whatever mathematics, technology, and science they need to deal with the que time for asking around, reading, and arguing; time for wrestling with unfamiliar counterintuitive ideas and for coming to see the advantage in thinking differentl

Moreover, any topic in science, mathematics, or technology that is taught in on lesson or unit is unlikely to leave a trace by the end of schooling. To take hold a concepts must not be presented to students just from time to time, but must be them periodically in different contexts and at increasing levels of sophistication.

Classroom Implications

Imagine for a moment that our Harvard graduates who failed to answer correct about the seasons are back in middle school. What might their classroom expe like if the teaching and learning are designed to achieve science literacy? How teacher help them better understand the physical phenomena that cause seas(

Research tells us that students come to school with their own ideas--some corr not--about almost every topic they are likely to encounter. With that in mind, ou teacher most likely begins a lesson by identifying students' preconceptions and held ideas about seasons and then addressing those that reflect faulty thinking ignores or dismisses students' intuition and misconceptions out of hand, their o are likely to win out in the long run.

Next, the teacher engages the students with the topic. Young people learn mos things that are tangible and directly accessible to their senses. Over time and v experience, they grow in their ability to understand abstract concepts, manipula reason logically, and generalize.

To help our Harvard graduates learn about seasons, for example, the teacher r groups of students to build models that illustrate the relationship between the s earth and then to demonstrate and explain the physical phenomena that produ assess whether the students genuinely understand the phenomena and to give opportunity to reflect on their own understanding, our teacher might ask them a seasons in Australia or even on Uranus. If we expect students to apply ideas ir situations, then they must practice applying them in novel situations.

The teacher's guide to the video *A Private Universe* describes how this approa

If students are given the time to observe, explore, and understand the apparen the sun and moon in the sky, to make models of the solar system based on the observations, and to test their predictions, they may miss out on some other to rest of their lives, however, these students will have a firm foundation for learni across the curriculum. They will have a head start in understanding gravity in p growing seasons in environmental science, and vision in biology. Understandin may even benefit students in art, adding to their comprehension of light and sh (Private Universe Project, 1994)

The timing and sequence of learning are also important. As illustrated in *Bench* teaching about the earth's rotation and axis with regard to the planet's seasons targeted for grades 6 through 8. The cause of the seasons is a subtle combinat and orbital geometry and of the effects of radiation at different angles. Students of the story at these grade levels; a more complete picture comes with the ben assigned to grades 9 through 12. A forthcoming Project

2061 publication, the *Atlas of Science Literacy,* will graphically depict the interc among benchmarks as they contribute to a student's growth of understanding c

Science Literacy Goals

Science literacy is a necessary and achievable goal for all students. Teachers, parents, and reformers have an opportunity to use the TIMSS data to make an case for science literacy efforts designed to

- Implement national and state benchmarks and standards that will help s backgrounds, abilities, and interests achieve science literacy;
- Encourage textbook publishers and developers to align their work with t and standards;
- Prepare educators to assemble standards-based curriculum materials ir programs;
- Provide teachers with the time, resources, expertise, and preparation ne understand and apply national and state standards in their classrooms;
- Build support for benchmarks and standards among families, communit leaders, higher-education faculty, and policymakers.

This kind of change takes time and collaboration. Patience and realistic expect crucial. But so is urgency; if we don't start down the path to improvement today ourselves in the same place with the same problems and the same learning ne the world is not waiting for us. The United States cannot meet the challenges o unless today's children have a better understanding of the world and how it wo science, mathematics, and technology is not an option for the citizens of the 21

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Programs

Education

AAAS Project 2061 Middle Grades Science Te Evaluation

Criteria for Evaluating the Quality of Instructional Support

Category I. Providing a Sense of Purpose

Conveying unit purpose. Does the material convey an overall sense of purpose and direction that is understandable and motivating to students?

Conveying lesson purpose. Does the material convey the purpose of each lesson and its relationship to others?

Justifying activity sequence. Does the material involve students in a l or strategic sequence of activities (versus just a collection of activities)?

Category II. Taking Account of Student Ideas

Attending to prerequisite knowledge and skills. Does the material sp prerequisite knowledge/skills that are necessary to the learning of the benchmark(s)?

Alerting teacher to commonly held student ideas. Does the material teachers to commonly held student ideas (both troublesome and helpful as those described in *Benchmarks* Chapter 15: The Research Base?

Assisting teacher in identifying own students' ideas. Does the mate include suggestions for teachers to find out what *their* students think ab familiar phenomena related to a benchmark before the scientific ideas a introduced?

Addressing commonly held ideas. Does the material attempt to addre commonly held student ideas?

Category III. Engaging Students with Relevant Phenomena

Providing variety of phenomena. Does the material provide multiple a

varied phenomena to support the benchmark idea(s)?

Providing vivid experiences. Does the material include activities that p firsthand experiences with phenomena when practical or provide studer a vicarious sense of the phenomena when not practical?

Category IV. Developing and Using Scientific Ideas

Introducing terms meaningfully. Does the material introduce technica only in conjunction with experience with the idea or process and only as needed to facilitate thinking and promote effective communication?

Representing ideas effectively. Does the material include accurate ar comprehensible representations of scientific ideas?

Demonstrating use of knowledge. Does the material demonstrate/mo include suggestions for teachers on how to demonstrate/model skills or of knowledge?

Providing practice. Does the material provide tasks/questions for stud practice skills or *using* knowledge in a variety of situations?

Category V. Promoting Student Thinking about Phenomen Experiences, and Knowledge

Encouraging students to explain their ideas. Does the material routi include suggestions for having each student express, clarify, justify, anc represent his/her ideas? Are suggestions made for when and how stude get feedback from peers and the teacher?

Guiding student interpretation and reasoning. Does the material incl tasks and/or question sequences to guide student interpretation and rea about experiences with phenomena and readings?

Encouraging students to think about what they've learned. Does th material suggest ways to have students check their own progress?

Category VI. Assessing Progress

Aligning assessment to goals. Assuming a content match between th curriculum material and this benchmark, are assessment items includec match the same benchmark?

Testing for understanding. Does the material include assessment tasl require application of ideas and avoid allowing students a trivial way out using a formula or repeating a memorized term without understanding?

Using assessment to inform instruction. Are some assessments eml in the curriculum along the way, with advice to teachers as to how they use the results to choose or modify activities?

Category VII. Enhancing the Science Learning Environmer

Providing teacher content support. Would the material help teachers improve their understanding of science, mathematics, and technology necessary for teaching the material?

Encouraging curiosity and questioning. Does the material help teach create a classroom environment that welcomes student curiosity, rewar

creativity, encourages a spirit of healthy questioning, and avoids dogma

Supporting all students. Does the material help teachers to create a classroom community that encourages high expectations for all students enables all students to experience success, and that provides all studer feeling of belonging in the science classroom?

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Continued: Helping Students Learn the Kinetic Molecular Theory

TOP OF PAGE ▲ HOME ◂ PRESS POLICY EDUCATORS STUDEN

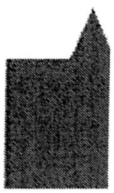
Programs

Education

Science for All Americans

Education for a changing future

Project 2061 began its work in 1985—the year Halley's Comet passed near Earth. Children who were just starting school then will see the return of the Comet. What scientific and technological changes will they also see in their lifetime? How can today's education prepare them to make sense of how the world works; to think critically and independently; and to lead interesting, responsible, and productive lives in a culture increasingly shaped by science and technology?



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read online.

With expert panels of scientists, mathematicians, and technologists, Project 2061 set out to identify what was most important for the next generation to know and be able to do in science, mathematics, and technology—what would make them science literate. The panels' recommendations were integrated into Project 2061's 1989 publication, *Science for All Americans*. *Science for All Americans* defines science literacy and lays out some principles for effective learning and teaching. In coherent prose, it articulates and connects fundamental ideas in science without technical vocabulary and dense detail.

What Is Science Literacy?
Project 2061 defines science literacy broadly, emphasizing the connections am
the natural and social sciences, mathematics, and technology. *Science for All A*
includes specific recommendations for learning in the following areas:

- *The Nature of Science* includes the scientific world view, scientific meth
and the nature of the scientific enterprise.
- *The Nature of Mathematics* describes the creative processes involved ir
theoretical and applied mathematics.
- *The Nature of Technology* examines how technology extends our abilitie
the world and the tradeoffs necessarily involved.
- *The Physical Setting* lays out basic ideas about the content and structur
universe (on astronomical, terrestrial, and sub-microscopic levels) and t
principles on which it seems to run.
- *The Living Environment* delineates basic facts and ideas about how livir
function and how they interact with one another and their environment.
- *The Human Organism* discusses human biology as exemplary of biolog
- *Human Society* considers individual and group behavior, social organiza
process of social change.
- *The Designed World* reviews principles of how people shape and contro

through some key areas of technology.

- *The Mathematical World* gives basic mathematical ideas, especially tho practical application, that together play a key role in almost all human e
- *Historical Perspectives* illustrates the science enterprise with ten examp exceptional significance in the development of science.
- *Common Themes* presents general concepts, such as systems and mo across science, mathematics, and technology.
- *Habits of Mind* sketches the attitudes, skills, and ways of thinking that a science literacy.

Science for All Americans also includes chapters on effective learning and teac reforming education, and next steps toward reform.

The Cornerstone of Reform

Science for All Americans presents a clear vision of science literacy that a varie audiences can use for myriad purposes. Widely recognized as the first step tov national standards in science for all students and a major influence on science many states, *Science for All Americans* serves as the foundation for current eff science education in the U.S. and abroad. Indeed, it is now available in Spanis be translated into Japanese.

Science for All Americans provides educators, parents, school administrators, a policymakers with a sense of where the K-12 curriculum should be aiming. It ca 12 teachers—no matter what grade or subject they teach—to fill in gaps in thei knowledge of science, mathematics, and technology. In addition, the essays in *Americans* provide a coherent picture of science literacy that can help in interp grade-specific learning goals in Project 2061's *Benchmarks for Science Literac* National Research Council's *National Science Education Standards.*

Beyond the K-12 Classroom

Because many college students are not science literate, higher education facul developing courses around the topics in *Science for All Americans*. Project 206 tool, *Resources for Science Literacy: Professional Development*, includes a va that address particular science literacy concepts. From Brown University to Ion courses in evolutionary biology, physics, technology and society, and computer systems, provide a sampling of the wide range of approaches colleges are taki mathematics, and technology education.

Many museums are also beginning to consider science literacy goals as they w reform in the schools. Boston's Museum of Science used Project 2061's princip effective learning and teaching to design a series of interactive exhibits. The Ci Institute of Science in Bloomfield Hills, Michigan, is redesigning its exhibits bas *for All Americans'* description of systems. And exhibits at Science Alive!—an in science center in Grand Rapids, Michigan—focus on four chapters in *Science f Americans.*

However it is used, *Science for All Americans* presents a unified vision of scien serves as a basis for discussions of the skills and knowledge that our nation's s have.

TOP OF PAGE ▲ HOME ◀ PRESS POLICY EDUCATORS STUDEN

Programs

Education

Benchmarks for Science Literacy

A tool for curriculum reform

Benchmarks for Science Literacy is the Project 2061 statement of what all students should know and be able to do in science, mathematics, and technology by the end of grades 2, 5, 8, and 12. The recommendations at each grade level suggest reasonable progress toward the adult science literacy goals laid out in the project's 1989 report *Science for All Americans*. *Benchmarks* can help educators decide what to include in (or exclude from) a core curriculum, when to teach it, and why.

Published in 1993 by Oxford University Press, *Benchmarks for Science Literacy* emerged from more than three years of work by Project 2061 staff in collaboration with teams of teachers at Project 2061's six School-District Centers, and with scientists and university consultants. It reflects the input of more than 1,300 individuals.

Benchmarks Literacy is a Oxford Univ Barnes & No

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Designing a Curriculum

Benchmarks is not a curriculum, a curriculum framework, or a plan for a curricu provides educators with sequences of specific learning goals that they can use core curriculum—one that makes sense to them and will help students achieve science literacy goals outlined in *Science for All Americans*. *Benchmarks* does any particular teaching methods or curriculum design, nor does it spell out goal performance. In fact, it encourages greater curriculum diversity than is commor help educators as they rethink their curriculum *Benchmarks:*

- describes levels of understanding and ability that all students are expec the way to becoming science literate;
- concentrates on the common core of learning that contributes to the sci all students while acknowledging that most students have interests and beyond that common core, and some have learning difficulties that mus considered;
- avoids language used for its own sake, in part to reduce sheer burden, prevent vocabulary from being mistaken for understanding;
- is informed by research on how students learn, particularly as it relates and grade placement of benchmarks; and
- encourages educators to recognize the interconnectedness of knowled these important connections into their curriculum units and materials.

Putting *Benchmarks* to Work

Project 2061 has spent several years considering the implications that specific

such as benchmarks have for curriculum and instruction. At workshops around the project has shared what it has learned with thousands of teachers, supervis and state leaders. These workshops introduce participants to standards-based highlight the usefulness of *Benchmarks* and Project 2061's other reform tools.

Who can benefit from *Benchmarks* and how? Together, *Science for All Americ Benchmarks for Science Literacy* are used by educators, teacher educators, cu developers, museums, and others for a variety of purposes:

Crafting Standards and Frameworks. Many states have modeled their own s frameworks after *Benchmarks* and *Science for All Americans.* A 1996 study of influence on reform revealed that many state curriculum documents cite Projec publications as key sources in their bibliographies, quote directly from the proje publications, or organize their own recommendations to parallel the 2061 docu even adopt benchmarks verbatim. Framework writers interviewed for the study *Benchmarks* strongly influenced decisions on what content to include.

Several national organizations have also used *Benchmarks* to guide their effort National Research Council drew on *Benchmarks* in developing its 1996 *Nation Education Standards.* And national organizations and agencies that support sta reform—the Statewide Systemic Initiatives program of the National Science Fo Department of Education's Eisenhower Mathematics and Science Education P the Association for Supervision and Curriculum Development to name a few—h Project 2061's publications extensively.

Materials Selection and Development. Project 2061 has developed a rigorou employing the learning goals presented in *Benchmarks*—that enables educato how well curriculum materials match science literacy goals. Educators have be *Benchmarks* together with Project 2061's materials-analysis procedure to infor adopting new curriculum materials and to determine whether and how to impro materials. Some curriculum-materials developers use the procedure as they cr that are aligned with the project's science literacy goals.

Developing and Analyzing Assessment. With the growing consensus on lea benchmarks, standards, and state and local goals—in science and mathematic becoming increasingly important for assessments to address those goals. Usin as well as *National Science Education Standards* and the National Council of T Mathematics standards, Project 2061 has developed an approach to analyzing the alignment of mathematics and science assessments with specific learning g

Project 2061 intends to form a consortium of educators from several states and districts who will use the project's assessment-analysis procedure to evaluate t of science and mathematics assessments with their own local and state standa the consortium will produce hundreds of mathematics and science assessment items that are aligned with benchmarks and standards.

Teacher Training. Colleges of education across the country incorporate *Bench* their science methods courses. Prospective teachers become familiar with the benchmarks; study the education research that guides their careful grade-level and consider how to focus lessons, teaching methods, and assessment on spe goals.

Informal Education. In support of K-12 science education reform, museums a centers across the country are beginning to consider national, state, and local s developing their exhibits and programs. They find the specificity of *Benchmark for All Americans* useful in interpreting their local or state standards, many of w on these publications. Museums also use *Benchmarks* to select appropriate th science exhibits, train docents in what to expect children of certain ages to kno to do in science, and plan professional development for teachers.

***Benchmarks* and National Standards**

Where they address common areas—that is, natural science content—the Nati Council's *National Science Education Standards(NSES)* and Project 2061's *Be*

Science Literacy are highly consistent. In fact, the National Research Council r
on *Benchmarks* in drafting its content standards, as stated in the introduction tc

> The many individuals who have developed the content standards sectio
> the *National Science Education Standards* have drawn extensively on a
> made independent use and interpretation of the statements of what all s
> should know and be able to do that are published in *Science for All Ame*
> and *Benchmarks for Science Literacy*. The National Research Council c
> National Academy of Sciences gratefully acknowledges its indebtednes
> seminal work by the American Association for the Advancement of Scie
> Project 2061 and believes that use of *Benchmarks for Science Literacy*
> state framework committees, school district curriculum committees, and
> developers of instructional and assessment materials complies fully witl
> spirit of the content standards. (*NSES,* p. 15)

Both visions of science literacy promote reducing the current glut of topics in th
and emphasize understanding of ideas central to science literacy over memoriz
vocabulary. And although they are organized differently, in most cases *Benchn*
NSES place ideas in the same grade ranges.

Both *Benchmarks* and *NSES* represent years of work by experts in science an
the extensive overlap between the two documents and the concurrence of the
Science Teachers Association signifies an informed consensus on the most im
knowledge and skills in science, mathematics, and technology. To help educat
and *Benchmarks* together more effectively, Project 2061's CD-ROM tool *Reso*
Science Literacy: Professional Development offers a detailed analysis of the si
differences of the two documents.

Benchmarks on Disk

To provide additional assistance to teachers and curriculum planners, *Benchmarks* is also available on disk in Windows and Macintosh formats. Users can browse through or search the full text of *Benchmarks,* quickly refer to other sections related to the benchmarks at hand, and consult the research base that informed the content and grade-level placement of the benchmarks.

Benchmarks on Disk features several "growth-of-understanding maps" of related benchmarks that trace student progress toward particular adult science literacy goals. Users can create and print their own groups of benchmarks to get a sense of how ideas in the curriculum connect across grades, disciplines, or subjects. The collection of maps on *Benchmarks on Disk* has been expanded in *Atlas of Science Literacy.*

Benchmarks Online

With support for standards-based reform and the use of the Internet growing, F
wanted to make *Benchmarks for Science Literacy* available in a flexible and wi
format. Therefore, Project 2061 has published *Benchmarks Online* on-line at
http://www.project2061.org/publications/bsl/online. Users can browse the full te
Benchmarks by chapter or use keywords to search the entire document. Hyper
the user to cognitive research and bibliographic references.

TOP OF PAGE » HOME « PRESS POLICY EDUCATORS STUDEN