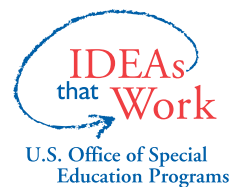




WEB-BASED RESOURCES FOR SCIENCE, TECHNOLOGY, AND ENGINEERING: TOOLS AND ACTIVITIES FOR TEACHING AND LEARNING

Curriculum Enhancement

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INTRODUCTION

Establishing challenging academic content standards in science and developing effective measures to assess student learning in this field are key goals of the federal No Child Left Behind Act of 2001 (NCLB) and many state education reform programs. Beginning in the 2007-2008 school year, states will be required to administer standards-based science assessments for all students at least once in grades 3-5, once in grades 6-9, and once in grades 10-12. (The standards themselves were supposed to have been in place by the beginning of the 2005-2006 school year.) NCLB intends that students with disabilities and those with limited proficiency in English be included in state testing and accountability provisions.

The challenge of providing an instructional environment where all students can meet high learning standards is felt most acutely at the school and classroom level, where resources are often scarce. Fortunately, the World Wide Web offers educators a significant number of resources for teaching science, technology, and engineering in the elementary and secondary grades. Most of these can be accessed at no cost. Although these resources are not primarily targeted at students with disabilities, educators should think about how the information contained in these resources can be applied to students who have diverse learning needs.

The diversity of tools and activities—including lesson plans, interactive models, video and audio, games, and more—can enhance curriculum and increase access to learning for all students, including those with disabilities. However, given the Web's vast, fast-changing, and loosely organized nature (not to mention its lack of quality controls), teachers may find it hard to locate appropriate sites. While this document is not a comprehensive catalog of the resources available online, it does offer guidance to some of the Web-based tools and activities that educators may find helpful. Please note that these links and references are provided solely for informational purposes and the convenience of readers; their inclusion does not constitute control, approval, or endorsement by the Access Center or CAST. Their quality or relevance to readers' needs is something that readers should evaluate for themselves.

The entries compiled here are grouped by type (general or subject-specific), and include information about the appropriate grade level(s) for the online activities and sample lessons. Following these entries is an annotated bibliography of online articles and books.

Both the links and the resources presented here were selected by CAST in fall 2005 according to two criteria: 1) they shed light on the kinds of effective research, classroom practices, and policies that support standards-based learning, and 2) they can be accessed free of charge via the Web. All links in this document were active as of the publication date. Given the oft-changing nature of the Web, we apologize in advance for any links that become inaccessible after publication.

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MATRIX SUMMARY OF RESOURCES

Resource	Grade Level	Content Area	Type	URL
Access Excellence	elementary, middle, high, college	Life Science	A graphics library, journal for educators, and teaching strategies	http://www.accessexcellence.org/
Agriculture in the Classroom	elementary, middle, high	Life Science	Science project ideas, interactive games, and agriculture info for students, and links and lesson plans for teachers	http://www.agclassroom.org/
American Memory	elementary, middle, high	Technology, Engineering	Lesson plans on the rise of Industrial America	http://memory.loc.gov/learn/lessons/theme.html
American Museum of Natural History Resources for Learning	elementary, middle, high	Science	Collection of 90 resources, including activities, articles, and curricular materials	http://www.amnh.org/education/resources/index.php
Annenberg Case Studies in Science Education	elementary, middle	Science	25 modules on approaches to teaching science	http://www.learner.org/resources/series21.html
Ask a Scientist	elementary, middle, high	Science, Math, Engineering	Responses to questions submitted to professional scientists	http://www.newton.dep.anl.gov/arch/ive.htm
ASEE EngineeringK12 Center	elementary, middle, high	Technology, Engineering	Links, lesson plans, engineer profiles	http://www.engineeringk12.org/
comPADRE: Resources for Physics and Astronomy Education	elementary, middle, high	Physical Science	Six collections of educational resources for students and teachers	http://www.compadre.org/portal/index.cfm
Educator's Reference Desk	elementary, middle, high	Science	Teacher-submitted lesson plans	http://www.eduref.org/cgi-bin/lessons.cgi/Science
ExploreLearning Gizmo Catalogue	middle, high	Science, Math	Catalog of interactive simulations	http://www.explorelearning.com/index.cfm?method=cResource.dspResourceCatalog

Fermilabryrith	middle, high	Physical Science	Games and links	http://www- ed.fnal.gov/projects/labyrinth/games
Frank Potter's Science Gems	elementary, middle, high	Science, Math, Engineering	Collection of lesson plans	http://www.sciencegems.com/
Gamequarium.com	elementary	Science	Links to online science games	http://www.gamequarium.com/scien ce.htm
Lesson Planet	elementary, middle, high	Science	Collection of lesson plans, some with worksheets and other instructional materials	www.lessonplanet.com
LessonPlansPage.com	preschool, elementary, middle, high	All	Teacher- submitted lesson plans and lesson ideas	http://www.lessonplanspage.com/in dex.html
National Science Digital Library (NSDL)	elementary, middle, high	Science, Technology, Engineering, Math	Resources in various formats--video, text, audio, interactive, data, etc.	http://nsdl.org
NASA Education	elementary, middle, high	Earth/Space Science	Articles, interviews, games, activities, and news on NASA and its missions	http://www.education.nasa.gov/
National Geographic Xpeditions	elementary, middle, high	Earth/Space Science	Lessons plans, activities, and maps	http://www.nationalgeographic.com/ xpeditions/
NOVA Teachers	middle, high	Science, Technology, Engineering	Interactive activities related to the sciences	http://www.pbs.org/wgbh/nova/teac hers/
Outstanding Science Trade Books	elementary, middle	Science	List of best science trade books for students	http://www.nsta.org/ostbc
Physical Sciences Resource Center	elementary, middle, high	Physical Science	Teaching and learning resources-- curriculum materials, classroom demonstrations, labs, articles	http://www.compadre.org/psrc/
Science Court Hands- On Activities	elementary, middle	Science	Activities for students that feature science	http://www.teachtsp.com/products/p roductextras/SCISCI/activities.asp

			experiment ideas	
Science Master	elementary, middle, high	Science, Technology	Lesson plans, activities, project ideas, and links	http://www.sciencemaster.com
Science NetLinks	elementary, middle, high	Science	Lesson plans, links, and student activities	http://www.sciencenetlinks.com
The Science Page	elementary, middle, high	Science	A list of links organized by resource type	http://sciencepage.org
SMILE Programs: Science and Mathematics Initiative for Learning Enhancement	elementary, middle, high	Science	A collection of single-concept lessons and related online resources	http://www.iit.edu/~smile
Southwest Biotechnology and Infomatics Center (SWBIC) Educational Resources	elementary, middle, high	Life Science	Classroom and lab activities, multimedia, lesson plans, and games	http://www.swbic.org/education/education.php
Teaching Plastics	elementary, middle, high	Physical Science	Teaching supports and videos	http://www.handsonplastics.com/
The Tech Museum of Innovative Design Challenge	elementary, middle, high	Technology, Engineering	Real world problems for students to solve and associated teacher supports	http://www.thetech.org/education/teachers/curriculum.php
TLC Elementary School	elementary, middle	Science	Lesson plans associated with a television show	http://school.discovery.com/ontv/tlc.html
Tramline's Virtual Field Trips	elementary, middle, high	Science	Virtual field trips on science topics	http://www.field-guides.com/trips.htm
University of South Carolina Center for Engineering and Computing Education, K-12 Lesson Plans	elementary, middle, high	Science, Math	Downloadable lesson plans and links	http://cece.engr.sc.edu/lessonplans.html
U.S. Geological Survey Educational Resources	elementary, middle, high, college	Earth/Space Science	Teaching modules, class activities, and links	http://education.usgs.gov/
Vocational Information Center	elementary, middle, high	Technology, Engineering	Links to resources on vocational and technical learning	http://www.khake.com/page82.html

Volcano World	elementary, middle, high	Earth/Space Science	Comprehensive site on volcanoes	http://volcano.und.nodak.edu/vw.html
The Why Files	middle, high	Science, Math	Articles on the science behind current events	http://whyfiles.org
Windows to the Universe	elementary, middle, high	Earth/Space Science	Images, movies, and data sets for students and tools, activities, workshops, and links for teachers	http://www.windows.ucar.edu/

GENERAL RESOURCES

American Museum of Natural History Resources for Learning

<http://www.amnh.org/education/resources/index.php>

This Web site provides students and educators with access to the American Museum of Natural History's extensive collection of scientific and educational materials—more than 900 resources in all. Resources are organized by topic (such as anthropology, astronomy, biology, earth science, paleontology), grade level, type of resource (activities, curriculum materials, articles for students, evidence and analysis, exhibition materials, and reference lists), and completion time (from less than one period to more than one week). The advanced search panel allows the user to identify material by any or all of these parameters. Lessons, projects, and activities include notes for suggested teacher use. There are also special, thematically grouped collections available for browsing.

Grade level(s): elementary school, middle school, high school

Advertising: none except references to museum products

Annenberg Case Studies in Science Education

<http://www.learner.org/resources/series21.html>

This Smithsonian-Harvard collaboration provides K-8 science teachers free access to 25 different modules in which teachers share their approaches to teaching science. The modules consist of half-hour videos and program guides. The case studies follow individual teachers over the course of an entire school year as they work to improve their instructional practice. Topics such as assessment, teaching diverse learners, developing critical thinking skills, and more are covered. Each module is divided into thirds: the teacher's background and the problem he or she chooses to address, the chosen approach and implementation, and the outcome with assessment by the teacher and an advisor. (Cost-free registration with an email address is required.)

Grade level(s): elementary school, middle school

Advertising: none

Ask a Scientist

<http://www.newton.dep.anl.gov/archive.htm>

Hosted by the Argonne National Laboratory and the U.S. Department of Energy's Office of Science, this site contains more than 18,000 questions submitted by K-12 teachers and students since 1991, and the answers provided by qualified scientists. The following topics are covered: astronomy, biology, botany, chemistry, computers, engineering, environmental and earth science, general science topics, materials

science, mathematics, molecular biology, physics, veterinary science, weather, and zoology. Users can browse the archived questions by subject area or search by keyword and can post new questions that have not been asked before. In addition there is a “question of the week” feature that highlights a student-scientist exchange. Both student- and teacher-oriented information on using the site is provided.

Grade level(s): elementary school, middle school, high school

Advertising: none

Educator’s Reference Desk

<http://www.eduref.org/cgi-bin/lessons.cgi/Science>

This site provides a vast collection of teacher-submitted lesson plans in science and other subjects. A searchable index enables users to identify lessons by specific concept area and grade level (preK-12). Also included is a guide to writing one’s own lesson plans, as well as a criteria guide to explain how lessons have been selected for inclusion in the database.

Grade level(s): elementary school, middle school, high school

Advertising: none

ExploreLearning Gizmo Catalogue

<http://www.explorelearning.com/index.cfm?method=cResource.dspResourceCatalog>

This Web site offers a catalog of modular, interactive simulations in math and science for teachers and students. The simulations, called Gizmos, are virtual manipulatives that are designed as supplemental curriculum materials that support state and national curriculum standards. The units are divided into groups—grades 6-8, 9-12, and college—and further divided by subject area. There are math manipulatives for post-secondary students as well. Gizmos are also listed by the state standards and textbook publishers with which they correlate. Most Gizmos include a handful of assessment questions for students to demonstrate what they learned from the exercise. Free 30-day trials are available but beyond that access to the site requires membership, and prices vary by district, school, and class size.

Grade level(s): middle school, high school

Advertising: none

Frank Potter's Science Gems

<http://www.sciencegems.com/>

This site is an extensive collection of lesson plans for the physical, earth, and life sciences, as well as for engineering and mathematics. The resources are searchable by category, subcategory, and grade level.

Grade level(s): elementary school, middle school, high school
Advertising: none

Gamequarium.com

<http://www.gamequarium.com/science.htm>

This site provides direct links to online science games on other Web sites. The links are grouped by subject (e.g., cells, ecology, energy, oceanography) and are quiz-style, crossword puzzles, fill-in-the-blanks, jigsaw puzzles, and concentration style, among others. Additionally, there is a page of links to student-created games. Created by an elementary school teacher, the games are aligned to Missouri and District of Columbia standards.

Grade level(s): elementary school
Advertising: none

Lesson Planet

<http://www.lessonplanet.com/>

Lesson Planet, a subpage of Education Planet, is an online warehouse for lesson plans in all subject areas. Users must have an account to access all site content. As this report is being prepared, account prices range from no cost (for very limited access) to \$25.00 per year (for full access). Users can search for materials by keyword, grade level, and rating (each lesson plan is rated on a 1-5 scale by a teacher). Science materials are broken down into subcategories (e.g., engineering, human body, space) that can be browsed. Some lesson plans come with additional material, such as worksheets, reference lists, or vocabulary lists. The site offers 30,000 links to lesson plans, of which approximately 8,000 are science-related.

Grade level(s): elementary school, middle school, high school
Advertising: none

LessonPlansPage.com

<http://www.lessonplanspage.com/index.html>

This site provides free teacher-submitted lesson plans and ideas for all subject areas. Lesson plans are available in printable formats for easy output. The science section is grouped by narrow grade-level ranges (preK–1, 2–3, 4–5, 6–7, and 8–12). Users can upload their own lessons to share with other educators. Other teacher resources on the site include a guide to writing lesson plans, a list of education links, motivational stories submitted by teachers, science project ideas, and math worksheets.

Grade level(s): preschool, elementary school, middle school, high school
Advertising: yes (banner and text ads)

National Science Digital Library (NSDL)

<http://nsdl.org/>

The National Science Digital Library (NSDL) is the National Science Foundation's online library of resources for educators. It was established "to provide organized access to resources and tools that support innovations in teaching and learning at all levels of science, technology, engineering, and mathematics education." The site is an index of education resource sites, and is searchable by keyword, subject, grade level, and media format (video, text, audio, image, interactive, and data). In addition, by using "NSDL at a Glance," users can browse a Java map of NSDL's collections.

Grade level(s): elementary school, middle school, high school
Advertising: none

NOVA Teachers

<http://www.pbs.org/wgbh/nova/teachers/>

This Web site, an online companion to the public television series NOVA, provides teachers with numerous resources related to science topics featured on the series. Resources include suggestions from other teachers, classroom activities, and interactive activities for students. A "Featured Teacher" section highlights a teacher who explains a lesson plan she or he has crafted around a particular episode. The interactive activities include games, puzzles, clickable maps, slide shows, and videos. The resources are organized by subject, such as technology/engineering, oceanography, physics, and so forth. While the related resources are offered free of charge, videos of the programs themselves must be purchased.

Grade level(s): middle school, high school
Advertising: links to PBS's online store

Outstanding Science Trade Books

<http://www.nsta.org/ostbc>

The National Science Teachers Association lists by year the best science trade books for children—with a special focus on K-8. Each year's list is organized according to subject (biography, earth and space science, life science, etc.). Entries include a short description of the book and an indication of which national science standard(s) it meets.

Grade level(s): elementary school, middle school
Advertising: none

Science Court Hands-On Activities

<http://www.teachtsp.com/products/productextras/SCISCI/activities.asp>

This Web site features five hands-on science activities for grades K–8 presented in a student-friendly format by Tom Snyder Productions/Scholastic, Inc. The activities, on the water cycle, work, inertia, sound, gravity, and statistics, each use a comic strip to pose a science question and then describe an experiment that will allow students to discover the answer. The activities are meant to complement Tom Snyder’s Science Court educational software products, but can be used independently as well. The descriptions of the software include information about the correlation of these products and exercise with national and state standards.

Grade level(s): elementary school, middle school

Advertising: Tom Snyder Productions/Scholastic, Inc. products

Science Master

<http://www.sciencemaster.com/>

This Web site includes lesson plans, activities, project ideas, and links to research sites. The site is divided by subject area—life science, space science, physical science, earth science, and technology. “Learning Galleries” provide photographs organized by topics.

Grade level(s): elementary school, middle school, high school

Advertising: yes

Science NetLinks

<http://www.sciencenetlinks.com/>

A service of the MarcoPolo Education Foundation, Science NetLinks provides lesson plans, Web links, as well as a number of fun and instructive interactive activities for students. The lessons are written for the teacher’s use but include student-ready materials (downloadable and online worksheets). All content on the site is labeled by grade level (K-2, 3-5, 6-8, 9-12) and by its corresponding Benchmark for Science Literacy, the science standards developed by Project 2061 of the American Association for the Advancement of Science (AAAS), a partner of the MarcoPolo Foundation.

Grade level(s): elementary school, middle school, high school

Advertising: none

The Science Page

<http://sciencepage.org/>

A catalog of links to science sites with lesson plans, activities, lab projects, and curriculum materials. The links are categorized by subject area (e.g., paleontology, physics, weather) and resource type (e.g., lesson plans, newsgroups, search engines).

Grade level(s): elementary school, middle school, high school

Advertising: none

SMILE Program: Science and Mathematics Initiative for Learning Enhancement

<http://www.iit.edu/~smile>

Hosted by the Illinois Institute of Technology, this Web site provides a collection of single-concept lessons contributed by K-12 teachers. Topics include physics, mathematics, chemistry, and biology, and there are approximately 200 lessons in each of these categories. The site also has an extensive list of related online resources.

Grade level(s): elementary school, middle school, high school

Advertising: none

TLC Elementary School

<http://school.discovery.com/ontv/tlc.html>

The Learning Channel's Scientific Inquiry Series consists of television programs and related standards-based lesson plans developed by teachers for teachers. The half-hour TV programs, which air Friday mornings, consist of several short segments that can be incorporated into existing lesson plans across a wide range of subjects. Programs are commercial-free and can be taped for classroom use. (They can also be purchased online.) Grades K-3 segments include "Protecting the Earth" and "Birds and Insects"; Grades 4-5 units include "The Rain Forest and the Desert" and "Electricity"; middle school segments include "How Plants Grow" and "Plate Tectonics."

Grade level(s): elementary school, middle school

Advertising: yes

Tramline’s Virtual Field Trips

<http://www.field-guides.com/trips.htm>

This Web site provides virtual field trips—that is, Web pages on a common subject that are strung together by TourMaker software into a cohesive Web tour. The field trips are organized by topic and grade level and are available free of charge. A cost-free trial version of the software is available for download so that educators can make their own tours. Users may post their own virtual field trips created with TourMaker for later use and to share with other educators. Most trips are accompanied by a page of teacher resources on the tour topic (e.g., volcanoes). The “standards” page details which trips are aligned with which national standards.

Grade level(s): elementary school, middle school, high school

Advertising: none, though linked pages may have ads

University of South Carolina (USC) Center for Engineering and Computing Education, K-12 Lesson Plans

<http://cece.engr.sc.edu/lessonplans.html>

This Web site contains downloadable K-12 lesson plans developed by teams of USC engineering students and by South Carolina teachers. The materials are divided into six subjects: light, magnetism, and electricity; forces, motion, and design; physical science; earth and space science; plants and animals; and math. In addition there is a page of links to science education Web sites. The lesson plans are not organized by grade level.

Grade level(s): elementary school, middle school, high school

Advertising: none

The Vega Science Trust

<http://www.vega.org.uk/>

The Vega Science Trust is a nonprofit organization based in the United Kingdom that offers free streaming videos on science topics. Most videos are lectures, discussions, and videos with well-known scientists, including some Nobel laureates. Videos are indexed by type (e.g., interview, lecture), subject, and scientist, and alphabetically. Additionally, the educational resources page hosts two videos designed for school use—a Buckyball workshop and a states of matter workshop—and worksheets and other materials that complement these lessons.

Grade level(s): middle school, high school

Advertising: none

The Why Files

<http://whyfiles.org/>

This Web site, a project of the University of Wisconsin, explains the science, math, and technology behind current events and news. Articles on a variety of science-related topics, from fuel cells to stem cells, are published online every two weeks. Articles usually include diagrams, charts, maps, or images related to the scientific principles or concepts presented. Past articles are archived and are indexed by subject and grade levels (5-8 and 9-12). Four interactive animations are available on lightning, snowflakes, tornadoes, and the physics of baseball.

Grade level(s): middle school, high school

Advertising: none

SUBJECT-SPECIFIC RESOURCES

The following Web sites provide content-area resources in one of the four major science areas—earth and space science, life science (biology), physical science (chemistry and physics), and technology and engineering—as well as specializations within each of these main topic areas.

Earth and Space Science

NASA Education

<http://www.education.nasa.gov/>

This Web site is a portal to articles, interviews, games, activities, and news related to NASA and its space missions. Resources are organized first by audience—educators, students, and kids—and then by grade level. NASA’s online education resources are largely divided by program (e.g., Solar System Exploration program, Educator Astronaut program); this site highlights program features and provides a search engine to link users to other Web resources.

Grade level(s): elementary school, middle school, high school

Advertising: none

National Geographic Xpeditions

<http://www.nationalgeographic.com/xpeditions/>

This site describes itself as the “home to the U.S. National Geography Standards—and to thousands of ideas, tools, and interactive adventures that bring them to life.” Besides

listing the standards, the site contains lesson plans and activities for grades K-12 organized by each standard and by grade level. In addition, there is an atlas section with hundreds of downloadable and printable maps. The Xpedition Hall is a virtual museum where students can play with exhibits that teach geography lessons and concepts organized by the standards.

Grade level(s): elementary school, middle school, high school

Advertising: logos of corporate sponsors

U.S. Geological Survey (USGS) Educational Resources

<http://education.usgs.gov/>

This Web site, titled “The USGS and Science Education,” organizes its resources by grade level: K-6, 7-12, and postsecondary. For each of these groups there are complete teaching modules, structured class activities, and Web resource links (usually to other USGS sites), all of which are in one of four subject areas: geology, geography, biology, or water resources. In addition, the site has a “Special Features” category that lists resource highlights; current features include the popular USGS map library, “The GIS Lab,” and videos and information about science careers. There is also a collection of resources that are linked to California state science standards.

Grade level(s): elementary school, middle school, high school, college

Advertising: none

Volcano World

<http://volcano.und.nodak.edu/vw.html>

This is a comprehensive site on volcanoes geared toward students, teachers, and the general public. It provides a volcano FAQ, a list of most recent eruptions, a volcano finder feature (volcanoes are indexed by world region, country, and name), a page of stories about volcano adventures, a glossary of terms, and a “Kids’ Door” page for younger users. Additionally, the “Teaching and Learning” page has lessons and experiment ideas for educators.

Grade level(s): elementary school, middle school, high school

Advertising: none

Windows to the Universe

<http://www.windows.ucar.edu/>

This Web site provides resources for learning about earth and space science. It includes images, movies, animations, and data sets for exploring these sciences as well as the historical and cultural ties between science, exploration, and the human

experience. All text content is written at three reading levels approximating elementary, middle school, and high school levels. Additionally, the “Teacher Resources” section provides tools, activities, workshops, and links, as well as a standards search function for internal pages that conform either to Michigan Essential Goals and Objectives for Science and Education (MEGOSE) or to National Science Education Standards (accessed through the site map).

Grade level(s): elementary school, middle school, high school
Advertising: none

Life Science (Biology)

Access Excellence

<http://www.accessexcellence.org/>

Access Excellence (AE), a Web site of the National Health Museum in Washington, DC, connects teachers and students to health and bioscience resources. The section titled “Resource Center” offers links by category and subject (e.g., biology, chemistry, genetics). The Web site also has a Graphics Gallery, that is, a visual library of x-rays, charts, diagrams, illustrations, and links to other graphics libraries and animation collections on the Internet. AE’s peer-reviewed journal, *Biology Ed Online*, which is written by and for K-16 educators, connects teachers with each other via a computer network forum, where they share best practices, activities, and resources. Other teacher resources include a section on virtual experiments, tours, and simulations; a section on integrating technology (teaching strategies and lessons integrating technology into the curriculum); and a specific list of teachers’ Web sites.

Grade level(s): elementary school, middle school, high school, college
Advertising: none

Agriculture in the Classroom

<http://www.agclassroom.org/>

A project of the U.S. Department of Agriculture, this Web site contains information for students and teachers. “Kids’ Zone” and “Teen Scene” provide information about agriculture, interactive games, and science project ideas for their respective age groups. The teacher resources page contains links to agriculture and education Web sites, lesson plans, and science experiment ideas. The lesson plans are quite extensive: most are 5-7 pages long and include activity sheets and/or blank charts. Links to similar sites sponsored by states are provided.

Grade level(s): elementary school, middle school, high school
Advertising: none

Southwest Biotechnology and Informatics Center (SWBIC) Educational Resources

<http://www.swbic.org/education/education.php>

This site connects students and teachers with resources relating to biology and biotechnology. The links are listed by resource type, which include classroom and lab activities, multimedia resources, lesson plans, educational games, supplemental materials, and others. Activities such as “DNA Fingerprinting” and “Watch an Enzyme Work” are meant to help students understand and gain practice in conducting scientific investigations.

Grade level(s): elementary school, middle school, high school

Advertising: none

Physical Science (Chemistry & Physics)

comPADRE: Resources for Physics and Astronomy Education

<http://www.compadre.org/portal/index.cfm>

This site hosts collections of Web resources for students and teachers of physics and astronomy. The six collections—the Physics Front, the Astronomy Center, the Physical Sciences Resource Center (reviewed below), The Nucleus, Physics To Go, and the Quantum Exchanges—each have a slightly different focus, but provide users with annotated links to education resources that are organized by grade level and topic.

Grade level(s): elementary school, middle school, high school

Advertising: none

Fermilabyrinth

<http://www-ed.fnal.gov/projects/labyrinth/games>

This Web site introduces the science and technology of the Fermi National Accelerator Laboratory (Fermilab), the home of the world’s largest particle accelerator. The site is a small collection of Web-based games on high-energy particle physics developed from selected hands-on exhibits at the Lederman Science Center. The site also contains links to other Lederman Science Center online features for educators and students.

Grade level(s): middle school and high school

Advertising: none

Physical Sciences Resource Center

<http://www.compadre.org/psrc/>

A service of the American Association of Physics Teachers, this site links to teaching and learning resources in the physical sciences and is organized by grade level (K-20), topic, and activity type. Resources include curriculum materials, classroom demonstrations, labs, online interactive learning material, and articles. The collection can be searched by keyword, author's name, and organization, or browsed by topic, type of resource, and grade level.

Grade level(s): elementary school, middle school, high school

Advertising: none

Teaching Plastics

<http://www.handsonplastics.com/>

This site provides free science investigation kits and other supports for teaching the chemistry and characteristics of plastics across the K-12 curriculum. Developed by the National Middle Level Science Teachers Association (NMLSTA) and produced and distributed by the American Plastics Council (APC), the curriculum kits meet national standards and are available for three grade ranges: K-4, 5-8, and 9-12. The site includes free videos that demonstrate how the classroom investigations work. Kits are free to teachers as well as to home-school parents. Materials may be downloaded directly from the Web site; supplemental materials are also available through postal mail.

Grade level(s): elementary school, middle school, high school

Advertising: logos of corporate sponsors

Technology/Engineering

American Memory

<http://memory.loc.gov/learn/lessons/theme.html>

The National Education Technology Standards and many state and local frameworks call for students to develop an understanding of the economic, political, and social impact of technological changes. The American Memory project of the U.S. Library of Congress offers a number of multimedia lesson plans on the rise of Industrial America, from 1876 to 1900. The impact of new technologies such as the telephone, electric lamps, and photography are explored in lessons that link to original source documents, archival photos, and early film footage.

Grade level(s): elementary school, middle school, high school
Advertising: none

ASEE EngineeringK12 Center
<http://www.engineeringk12.org/>

This site, developed by the American Society for Engineering Education, offers K-12 resources, including reports on best practices, profiles of “cool” engineers, lesson plans, and links to teacher resources and readings and to other lesson-plan clearinghouses.

Grade level(s): elementary school, middle school, high school
Advertising: ASEE products, logos of corporate sponsors

The Tech Museum of Innovation Design Challenge
<http://www.thetech.org/education/teachers/curriculum.php>

This site, created by the Tech Museum of Innovation, aims to teach engineering design principles by offering authentic, real-world problems in collaborative settings. More than two dozen Design Challenge projects are outlined, including topics such as building seaworthy boats and earthquake-proof buildings. The lessons align to California state standards as well as those of the International Technology Education Association. Many include teacher notes, hand-outs, and post-lesson activities. An explanation and visual display of the pedagogy underlying the concept of Design Challenge lessons is included. Design Challenge materials are available for download as PDF files.

Grade level(s): elementary school, middle school, high school
Advertising: none

Vocational Information Center
<http://www.khake.com/page82.html>

In the 1990s, teacher Kathryn Hake began cataloging resources and weblinks to support vocational and technical learning. The result is the Vocational Information Center. The URL listed here points to lesson plans and activities for subjects such as electricity, engineering, carpentry, and construction. Many of the linked lessons—including “Static Electricity,” “Understanding Flight,” and “Building the Chesapeake and Ohio Canal”—meet national and/or state science standards.

Grade level(s): elementary school, middle school, high school
Advertising: none

ANNOTATED BIBLIOGRAPHY OF SELECTED ONLINE RESOURCES

American Association for the Advancement of Science. (1993). *Benchmarks for science literacy*. New York: Oxford University Press. Retrieved December 6, 2005, from <http://www.project2061.org/publications/bsl/online/bolintro.htm>

This report was produced as part of Project 2061, a long-term initiative of the American Association for the Advancement of Science (AAAS) to help all Americans become literate in science, mathematics, and technology. The report is a companion to an earlier report, *Science for All Americans* (AAAS, 1989), which defined scientific literacy and recommended specific K-12 science literacy standards. *Benchmarks for Science Literacy* presents specific benchmarks describing the knowledge and skills students should have at various K-12 grade levels. These benchmarks were developed by six school-district teams, together with consultants and Project 2061 staff, with input from hundreds of teachers as well as scientific and educational organizations. The report is intended as a tool for designing a curriculum that is consistent with the science literacy standards recommended in *Science for All Americans*.

American Association for the Advancement of Science. (1998). *Ten questions to ask your neighborhood school about local science education*. Retrieved December 6, 2005, from <http://www.project2061.org/publications/articles/questions/10questions.htm>

This Project 2061 brief is meant to facilitate communication among parents, teachers, and school administrators about a school's science curriculum. Questions deal with national benchmarks, teacher support and collaboration, and learning styles. The brief is also offered in Spanish.

Anderson, R. D. (2002). Reforming science teaching: What research says about inquiry. *Journal of Science Teacher Education*, 13(1), 1-12. Retrieved December 6, 2005, from <http://web.cortland.edu/meyerd/anderson2002.pdf>

This journal article addresses questions about inquiry as it relates to science teaching and learning. Anderson notes that while inquiry is a central component of science education reform, there are many questions surrounding it. Through review of the research literature and the National Science Education Standards,

Anderson clarifies usage and definitions of the term, the outcomes of inquiry teaching, the feasibility of widespread inquiry teaching, the barriers to inquiry teaching, and means to support inquiry teaching.

Burgstahler, S. (2003). *Working together: Science teachers and students with disabilities* (DO-IT Brief). Seattle, WA: University of Washington. Retrieved December 6, 2005, from <http://www.washington.edu/doit/Brochures/Academics/working.teachers.html>

Burgstahler emphasizes the benefits to academic and career success of a partnership between students with disabilities and their science teachers. This short article lists specific challenges students with disabilities may confront with respect to gaining and demonstrating science knowledge, and identifies accommodations for helping students to overcome each one.

Chalufour, I., Hoisington, C., Moriarty, R., Winokur, J., & Worth, K. (2004). The science and mathematics of building structures. *Science and Children*, 41(4), 30-34. Retrieved December 6, 2005, from <http://cse.edc.org/pdfs/products/sciMathBldgStruct012004.pdf>

A preschool teacher and a group of curriculum developers describe a unit that integrates math and science instruction into block play. The article details the unit and specifies how it connects to national education standards in science and mathematics.

Champagne, A. (1999). *Bringing the science assessment standards into the classroom*. Albany, NY: Center on English Learning & Achievement. Retrieved December 6, 2005, from <http://cela.albany.edu/publication/article/science.htm>

This essay is based in part on the Center on English Learning & Achievement's project on Mathematics and Science Literacy. Champagne acknowledges that the emphasis on assessment in standards-based science reform can be frustrating and overwhelming for teachers. In this essay he suggests ways that the National Science Education Standards' (NRC, 1996) Assessment Standards can help science teachers to develop science literacy and not merely test it.

Donovan, M. S., & Bransford, J. D. (2005). *How students learn: Science in the classroom* (National Research Council). Washington, DC: National Academy Press. Retrieved December 6, 2005, from <http://www.nap.edu/books/0309089506/html/>

Donovan and Bransford note that new guidelines and standards for science education suggest a different approach to teaching. This report for teachers presents illustrative examples of science instruction that are consistent with the guidelines of the National Research Council (1996, 1999) and the American Association for the Advancement of Science (1993).

Hakim, J. (2002). The story of the atom. *American Educator*, 26(1), 12-25. Retrieved December 6, 2005, from http://www.aft.org/pubs-reports/american_educator/spring2002/Atom.pdf

In this narrative written for middle school students and their teachers, Hakim describes the long process of scientific hypothesizing, testing, and discovering of the atom. In tracing the quest from Ancient Greece to Einstein, Hakim demonstrates the investigative and creative challenges faced by scientists. The article also shows the potential for colorful informational text to convey complex ideas of physics. The article includes sidebars showing simple in-class exercises that students and teachers can use to demonstrate those ideas.

Hug, B., Krajick, J. S., & Marx, R. W. (2005). Using innovative learning technologies to promote learning and engagement in an urban science classroom. *Urban Education*, 40(4), 446-472. Retrieved December 6, 2005, from <http://uex.sagepub.com/cgi/reprint/40/4/446>

Recent reform movements within the United States have called for science for all and educational reforms to support this goal. In light of these reform movements and concerns regarding learning within urban schools, science educators and policy makers have pushed for the incorporation of learning technologies within schools as a way of creating equity and promoting learning among diverse learners. The Center for Learning Technologies in Urban Schools has been working to create and adopt standards and project-based science curricula in a large systemic reform effort. A core challenge of this partnership has been to embed learning technologies within these units to support active and engaged learning. This article examines how two interactive learning technologies embedded within an extended project-based science curriculum unit are capable of engaging urban students in actively learning key science concepts.

Kesidou, S., & Roseman, J. (2002). How well do middle school science programs measure up? Findings from Project 2061's curriculum review. *Journal of Research in Science Teaching*, 39(6), 522-549. Retrieved December 6, 2005, from <http://www.project2061.org/publications/articles/curriculum/jrst.htm>

Kesidou and Roseman describe a study in which middle school science programs were evaluated for how well they supported student learning in a standards-based setting. Using research-based criteria, teams of teachers and specialists identified typical strengths and weaknesses of nine widely used science programs. They found that while the programs generally presented key ideas called for in the standards, elaborate details or unrelated ideas tended to obscure their presentation. Also, the programs often did not convey to students a sense of purpose for the units of study or engage them in ways that would allow them to connect essential ideas and phenomena to their everyday lives. The authors recommend using the findings from this research to guide development of more effective science curriculum.

Martin-Hansen, L. (2004). What to toss and what to keep in your curriculum. *Science Scope*, 28(1), 22-24. Retrieved December 6, 2005, from http://science.nsta.org/enewsletter/2005-01/ss0409_22.pdf

As teachers adopt a curriculum, they often have the false notion that every page of the text must be read in order to cover all standards required by the state. In fact, nearly all middle school science texts contain so much detail that they are confusing to students. This article encourages science teachers to use the *Atlas of Scientific Literacy* to streamline their curriculum and create more time for meaningful science lessons.

National Academy of Sciences. (1998). *Teaching about evolution and the nature of science*. Washington, DC: National Academy Press. Retrieved December 6, 2005, from <http://books.nap.edu/html/evolution98/>

This book addresses frequently asked questions about Darwin's evolution theory and the scientific process in general. The authors review fossil evidence and other observational data, and discuss ways of teaching that respect religious beliefs in potential opposition to Darwin without compromising the inclusion of essential information in biology instruction. The document includes scripts of teacher-teacher and teacher-student discussions, explanations of how the national science standards address evolution, and suggested instructional activities and teaching materials.

National Research Council. (1996). *National science education standards*. Washington, DC: National Academy Press. Retrieved December 6, 2005, from <http://www.nap.edu/books/0309053269/html/index.html>

This document offers a comprehensive portrait of what students need to know, understand, and be able to do to be scientifically literate at different grade levels. It emphasizes the need to provide all students with the opportunity to learn science, offering them access to skilled professional teachers, adequate classroom time, a rich array of learning materials, accommodating work spaces, and the resources of the communities surrounding their schools. In addition to specific content requirements, the standards address instructional approaches, assessment, professional development, and system-wide supports for effective teaching. Divided into K-4, 5-8, and 9-12, the standards cover general science concepts as well as specific areas such as physical science, life science, technology, earth and space science, and the history of science.

National Science Teachers Association. (1998). *NSTA position statement: National science education standards* (Brief). Arlington, VA: Author. Retrieved December 6, 2005, from <http://www.nsta.org/positionstatement&psid=24&print=y>

This statement by the NSTA board of directors provides a concise rationale for standards,* and a bulleted list of key features of standards-based science programs and the supports needed to make their implementation successful, such as teacher professional development. This brief offers a concise tutorial for those unfamiliar with standards or the discourse around them.

Northwest Regional Education Laboratory. (2005). Science under the microscope. *Northwest Education* 10(3), 1-46. Retrieved December 6, 2005, from <http://www.nwrel.org/nwedu/10-03/cloak/whole.pdf>

In this special issue, authors from Northwest Regional Education Laboratory (NWREL), one of the nine Regional Education Laboratories supported by the U.S. Department of Education, examine how educators in the northwest region are responding to new science standards and accountability mandated by the No Child Left Behind Act. Articles include discussions of portfolio assessments, inquiry-based learning versus direct instruction, interviews with leading scientists offering advice to teachers about effective science instruction, Web-based resources, and more.

Palincsar, A. S. (2005). *Reading in science: Why, what, and how* (Brief). Washington, DC: National Science Resources Center. Retrieved December 6, 2005, from <http://nsrconline.org/pdf/ReadingInScienceEssay.pdf>

In this essay, reading researcher Palincsar discusses ways to incorporate reading into elementary school science instruction, something national science standards identify as important. Palincsar addresses several important questions: What role can informational texts play in developing science knowledge, vocabulary, and skills? How might these texts complement and support hands-on, inquiry-based science learning? What are some earmarks of effective science texts? The essay includes a case study from a fourth-grade classroom in which a teacher used both text and firsthand investigations to guide students in learning about how light interacts with materials.

Rillero, P. (1994). *Doing science with your children* (ERIC Digests). Columbus, OH: ERIC Clearinghouse for Science Mathematics and Environmental Education. (ERIC Document Reproduction Service No. ED372952.) Retrieved December 6, 2005, from <http://www.ericdigests.org/1995-1/science.htm>

This brief offers general suggestions for parents of grade-school students to stimulate science learning, discussion, and hands-on activities both at school and in the community.

St. John, M., Carroll, B., Century, J., Eggers-Pierola, C., Houghton, N., Jennings, S., & Tibbitts, F. (1999). *The principals of educational reform: Supporting mathematics and science teaching in your school: A handbook for elementary and middle school*

principals. Inverness, CA: Inverness Research Associates. Retrieved December 6, 2005, from <http://www.inverness-research.org/reports/nyssi/nyprinmonog.pdf>

Written for the New York State Department of Education, this monograph aims to support and guide K-8 school principals in improving science and math education at the building level through standards-based measures. The authors rely on the voices of principals to shape discussions of program assessment, teacher leadership teams, professional development, and selection of curricular materials.

Stepanek, J. (1998). *Engaging families in mathematics and science education*. Portland, OR: Northwest Regional Education Laboratory. Retrieved December 6, 2005, from <http://www.nwrel.org/msec/book5.pdf>

Stepanek suggests a variety of resources and strategies to strengthen school-home partnerships. This booklet, part of Northwest Regional Education Laboratory's *Just Good Teaching* series, provides practical ideas for engaging parents in their children's science and math education, including tips for supporting homework, at-home activities, and parent-teacher communication.

U.S. Department of Education. (2005). *Helping your child learn science*. Washington, DC: Author. Retrieved December 6, 2005, from <http://www.ed.gov/parents/academic/help/science/science.pdf>

This 70-page booklet offers a number of activities for families with children in grades preK-5 to make learning experiences out of everyday routines. The first half includes suggestions for making science experiments at home and guides for making the most of visits to community resources, such as museums, zoos, aquariums, and farms. The second half provides a list of resources, such as Web sites, TV programs, books, magazines, and science camps. The publication also has a section titled "Working with Teachers and Schools" and makes frequent reference to the No Child Left Behind Act and science standards.