Appendix E

Science for All: Including *Each* Student

A major theme in the *National Science Education Standards* is that science is for all students, and that all students should have the opportunity to attain high levels of scientific literacy. The purpose of this appendix is to elaborate on this theme and to offer practical suggestions for engaging a diverse student body in high-quality science education.

This appendix emphasizes working with students, such as girls, minorities, or students with disabilities, who traditionally receive unequal attention in the science classroom. We focus upon students with disabilities for two reasons. First, the move toward inclusion—educating students with disabilities in general education classrooms rather than in segregated settings—is increasingly the norm rather than the exception. Second, when we think about how to address students' disability-related needs, we often come up with approaches and curricula that help all students succeed in science.

MARY LEVIN, DO-IT PROGRAM

As an early childhood educator, you are well attuned to differences among the children in your classroom. Children enter school with different experiences, background knowledge, and learning styles. Between kindergarten and sixth grade, they will undergo a number of major developmental changes, and not all children in a given grade will reach particular developmental milestones at the same time. Practices that are used in early childhood education, such as presenting information in a variety of formats, exploring topics through a variety of activities, and continual informal assessment, will serve you well in helping all students succeed.

All *Means Each and Every Student*

The focus on "all" represents a significant change in our expectations about science education and ideas about who can do science. It used to be that only a small percentage of students—usually boys, usually white, usually nondisabled—was expected to be interested and to do well in science. Now it is clear that the demands of a technological society require every person to be a capable science thinker and informed decision maker. This is why "all" means each and every student: students with disabilities as well as nondisabled students, girls as well as boys, students of color as well as white students, students from low-income families as well as from high-income families.

To ensure that each student learns science, special attention must be paid to those groups who have traditionally been underrepresented in science. We still face gaps in science participation and achievement based on such factors as gender, race and

Diversity Among Scientists

While we remember famous Nobel Prize winners, inventors, and scientists, we often forget the tens of thousands of other scientists who are women and men of all races and ethnicities, many of whom have disabilities. Many people have heard of George Washington Carver, Marie Curie, and Stephen Hawking, but there are other notable scientists such as:

- Temple Grandin, an internationally recognized designer of livestock handling equipment. She currently serves as assistant professor of animal science at Colorado State University. Temple Grandin is autistic.
- David James, a tenured associate professor of mathematics at Howard University. He conducts research on differential topology and computer modeling and is the recipient of a Martin Luther King and Rosa Parks Visiting Professorship Award from Wayne State University in Detroit. David James is African-American and deaf.
- Geerat J. Vermeij, a preeminent evolutionary biologist and paleontologist. He is a professor at the University of California-Davis, and has been awarded MacArthur and Guggenheim fellowships. Geerat Vermeij is blind.

Teachers make an important difference
Temple Grandin, David James, and Geerat Vermeij don't fit the stereotypes of scientists and mathematicians. Part of the reason for their success is teachers—teachers who encouraged them, believed in them, and taught ways that facilitated achievement and interest.

Good teachers helped me to achieve success. I was able to overcome autism because I had good teachers. At age 2 ½ I was placed in a structured nursery school with experienced teachers.... Children with autism need to have a structured day, and teachers who know how to be firm and gentle.
—Temple Grandin (1998)

Mrs. Saplow saw to it that I became a fully responsible member of her class. Her sunny, extroverted personality created a forgiving atmosphere in which integration was natural, even inescapable. My classmates never uttered rude remarks about blindness, and the enterprising Mrs. Saplow never met a project or an activity in which I could take no part.... Full inclusion to Mrs. Saplow was not merely an empty phrase or a distant bureaucratic mandate; it was a state of mind, the manifestation of a deep conviction that the blind should be treated with equality and dignity along with everyone else.
—Geerat Vermeij (1997)

ethnicity, and disability, and we are far from having everyone achieve scientific literacy and ability.

Equity: From Access to Outcome

It was once believed that simply offering equal opportunity would make science available to everyone. The assumption was that if the door was open, students would enter, learn, and thereby end the differences in participation and achievement based on such factors as race, ethnicity, gender or disability. But students came through the door with different levels of experience and skills. Different groups of students received very different degrees of welcome.

Although opportunity is a prerequisite for learning, the *Standards* emphasize outcomes of learning. The *Standards* recognize that although important, access and treatment are not ends in themselves. The goal is that all students, independent of race, ethnicity, gender, or disability, will learn and be able to do science.

Equity means supporting students to achieve high-level outcomes. It does not mean treating all students the same. Different children learn differently and may need different instructional strategies to be successful in science. Not all students will achieve at the same level. But their differences in achievement should not be based on race, ethnicity, gender, or disability. Full access and fair treatment are important means to the end, but the process must lead to results—to achievement of the *Standards* by each student.

Start with the Strengths and Strengthen the Weaknesses

Too often, we focus on what students can't or don't do, especially when working with students with disabilities or from other groups that have traditionally been underrepresented in science. Yet all students have unique experiences and knowledge that can contribute to science learning. When we recognize this and

switch our initial focus from deficit to strength, we can enhance the science experience not just for students from underrepresented groups but for all learners.

Consideration of the strengths that students bring to science should permeate all aspects of science education, including how we teach and structure classroom interactions, how we assess students, and how we select and present content. Science requires invention, innovation, and the continuous application of alternative perspectives and hypotheses. Learning environments that build on the strengths of all students will result in higher-quality education for everyone.

Building on students' strengths also means identifying where students need help or where they didn't get equal opportunities in prior education. It makes sense to compensate for the opportunities students might have been denied. For example, a girl who has not had a fair chance in the block corner in preschool may need opportunities to build with materials and learn from experience about creating stable foundations and supporting height and arches. Or a disabled student who has had less opportunity to explore on his own may need experiences that will enable him to investigate his environment.

It is not that students don't have real weaknesses to identify and address. Rather, educators must identify how students' differences or limitations affect the learning experience, instead of letting economic background or physical disability define the student.

Equity in Practice

Science for all is "easy to say, hard to do" (Malcom, 1994). Teachers are the key to creating equitable science classrooms and learning experiences for all children. The *Standards* emphasize constructivism and inquiry, which are central to equity. Building on prior knowledge and experience can help students validate their identities, and help them see the science in their lives and communities. Inquiry, combined with high-quality learning outcomes, can be a powerful tool not just for pursuing scientific questions but for helping students take charge of their own learning, assert their own views, and become strong thinkers, communicators, and actors.

Be Specific About Differences or Limitations

Michael, a third grader, struggles when asked to make predictions about the outcomes of events presented in stories that his teacher reads out loud. Does this mean that Michael is incapable of the higher-order thinking required for science? Not at all. It turns out that Michael—who is a keen observer of his environment and loves to draw—is fully capable of making predictions, but Michael is a visual learner and needs visual support. If the events are presented to him visually through pictures, demonstrations, or hands-on activities, he readily predicts their outcomes.

Below are strategies for supporting a diverse group of students to ask questions, gather information, conduct investigations, and analyze and present findings. These suggestions are based on research and work in progress.

1. Guide students as they begin to engage in the inquiry process.

Some students may have had more encouragement, practice, and opportunity than others to ask questions, explore, and make sense of their investigations. This is because of assumptions our society makes about what different groups of people may be able to do. For example, a common misconception is that children with disabilities are unable to participate in hands-on science investigations because of their disability, which can result in the exclusion of students with disabilities from such activities. Consequently, students with disabilities may come to believe that science is something that they can't do. As another example, traditional gender socialization in some cultures rewards young girls for being neat, quiet, and not making mistakes. These messages may lead girls to believe that science investigations—which often involve

getting dirty, taking intellectual risks, and challenging existing explanations—are not appropriate for them.

Such societal expectations, which counter the notion that all students can learn science, must be carefully addressed. Fostering inquiry in culturally sensitive ways may mean learning more about how members of that culture question one another and build knowledge. To help reticent students guess, hypothesize, and wonder aloud, create safe environments where contributions are encouraged. Don't allow teasing or negative sanctions to be attached to wrong or even "silly" answers.

Value the variety of approaches that children use to solve problems. There is more than one way to do science and the expansion of scientific methodologies has led to new discovery and new fields of inquiry. For example, the observation methods used by Jane Goodall and Sarah Blaffer Hrdy have changed much of what we know about primate behavior. Barbara McClintock won a Nobel Prize for her work on the DNA of corn by "listening" to her corn plants and trying to see the world from their perspective. These discoveries are often cited as evidence of how diverse perspectives and support for innovation contribute to better science.

2. Make information resources available in multiple formats.

Students differ in how they learn best. Some students learn well from lectures, some from visual media (such as pictures, graphs, videos, or diagrams), while others like to learn from text. No single format will be effective or even accessible to all students in your classroom. Every student learns better if the content is presented in multiple formats, and for some a given format is necessary to gain access to information. For example, both deaf students and hearing students who are visual learners may find images more comprehensible than verbal descriptions. Many early-childhood programs give students the opportunity to learn through pictures, by listening to stories, by acting on objects and materials, by reading, and by singing songs.

Using multiple means and media serves students with disabilities well. You can support disabled children by providing access to information in a format in which they learn best. At the same time, help students become more proficient with less ideal formats by engaging with the content and building on students' curiosity.

The Full Option Science System (FOSS) is one example of a specialized curriculum that is useful for all students. FOSS was originally designed to serve students with disabilities, well before the *Standards* were developed. As FOSS's hands-on, inquiry-based approach to science gained widespread acceptance, FOSS itself was mainstreamed and used with all students, and now is frequently recommended and used.

3. Give students opportunities to express their ideas in multiple formats.

Teachers of young students whose literacy skills are still emerging know that students' writing often provides only a limited lens on what they have learned. Using writing tasks to assess learning particularly puts at a disadvantage those students who are more artistically inclined or who have difficulty writing because of a disability. Additional options for student expression that have been used successfully in the science classroom include oral responses, audio recordings, artwork, music, drama, photography, video, and sign language. Multimedia computer programs such as *KidPix* (Broderbund) or *ClarisWorks* (Claris Corporation) also offer students multiple options for expressing ideas through images, animations, sounds, and words in limitless combinations.

4. Make the process of investigation fully accessible.

Conducting experiments, manipulating materials, and using tools are integral to science inquiry. Pay attention to physical access by choosing materials and equipment that everyone can get to and handle. Encourage explo-

ration using different modalities to ensure that students with disabilities and students with diverse learning styles can participate in hands-on activities. If the focus is on one particular property of an object (e.g., sound), explore how this property can be described using different modalities (e.g., touch/vibration). This might allow deaf students and other students with visual learning styles to make significant contributions to this activity, and lead to interesting discussions about how one modality may not translate into another. However, do not assume a student's need for accommodation is based on a disability. Ask the students and their parents what they might need or how their comfort can be increased during an activity.

Don't exclude students from an activity because you worry that they will get distracted or hurt, or break the equipment. Take proper safety precautions (such as using protective glasses), give careful instructions, supervise, and create a calm environment when doing hands-on science with all children. If you conduct accessible learning activities, devise a way for all children to participate safely—for example, use desks and lab tables that are the right height for wheelchairs, or use science equipment that can be easily held and manipulated. Pair students as lab or classroom partners and they can build relationships to support each other's strengths and needs.

Accessible Tools and Equipment

The following resources provide information about science tools and equipment that are accessible to students with disabilities.

American Association for the Advancement of Science (AAAS). (1991). *Laboratories and Classrooms in Science and Engineering.* Washington, DC: Author.

Barrier Free Education, <http://barrier-free.arch.gatech.edu/>. Georgia Tech's Barrier Free Education Web site is a resource site helping students with disabilities gain access to math and science education. The site is intended to inform and assist students with disabilities, and their parents and teachers.

Underrepresented Groups

The following resources provide information about scientists and mathematicians from underrepresented groups.

American Association for the Advancement of Science (AAAS). (1996). *Stepping into the Future: African-Americans in Science and Engineering.* Washington, DC: Author.

Lakes-Matyas, Marsha and **Haley-Oliphant, Ann** (Eds.) (1996). *Women Life Scientists: Past, Present, and Future.* Bethesda, MD: American Physiological Society.

Lang, Harry G. (1994). *Silence of the Spheres: The Deaf Experience in the History of Science.* Westport, CT: Bergin & Garvey.

Lang, Harry G. and **Meath-Lang, Bonnie.** (1995*). Deaf Persons in the Arts and Sciences: A Bibliographical Dictionary.* Westport, CT: Greenwood Press.

Stern, Virginia W. and **Summers, Laureen.** (Eds.) (1995). *AAAS Resource Directory of Scientists and Engineers with Disabilities.* Washington, DC: American Association for the Advancement of Science.

Triana, Estrella M., Abbruzzese, Anne, and **Matyas, Marsha L.** (Eds.) (1992). *Stepping into the Future: Hispanics in Science and Engineering.* Washington, DC: American Association for the Advancement of Science.

Vermeij, Geerat J. (1998). *Privileged Hands.* New York: W. H. Freeman & Co.

Woods, Michael, with **Blumenkopf, Todd A., et al.** (Eds.) (1997). *Working Chemists with Disabilities: Expanding Opportunities in Science.* Washington, DC: American Chemical Society.

Internet resources

Deaf and Hard of Hearing Professionals in Science
http://www.gallaudet.edu/~mssdsci/rolemodels.html

Women in Science
http://library.thinkquest.org/20117/

African Americans in Science
http://www.lib.lsu.edu/lib/chem/display/faces.html

Accessible Software and Web Sites

The following organizations have information for educators about accessible design of computer software and Web sites:

Center for Applied Special Technology (CAST)
39 Cross Street, Suite 201
Peabody, MA 01960
TEL 978-531-8555
TTY 978-538-3110
FAX 978-531-0192
EMAIL: cast@cast.org
http://www.cast.org/

CAST is an educational, not-for-profit organization that uses technology to expand opportunities for all people, including those with disabilities. Available through its Web site is Bobby, a Web-based tool that analyzes Web pages for their accessibility to people with disabilities.

The CPB/WGBH National Center for Accessible Media (NCAM)
WGBH Educational Foundation
125 Western Avenue
Boston, MA 02134
TEL/TTY 617-300-3400
FAX 617-300-1035
EMAIL ncam@wgbh.org
http://www.wgbh.org/wgbh/pages/ncam/

NCAM is a research and development facility that works to make media accessible to underserved populations such as people with disabilities, speakers of minority languages, and people with low literacy skills. This Web site includes guidelines for evaluating software and Web sites for accessibility to people with disabilities.

Equal Access to Software and Information (EASI)
Rochester Institute of Technology
c/o Teaching, Learning & Technology Group
PO Box 18928
Rochester, NY 14618
TEL 716-244-9065
EMAIL easi@tltgroup.org
http://www.rit.edu/~easi/

The EASI Web site is a resource to the education community by providing information and guidance in the area of access-to-information technologies by individuals with disabilities. It includes information about how to evaluate Web sites for accessibility.

5. Make role models available.

Role models allow students to see their own concerns reflected in science and math, and can help develop students' interest in these disciplines. Provide students with opportunities to learn about the contributions of scientists and mathematicians from underrepresented groups. Use materials in which the stories, examples, and images reflect diversity; avoid stereotypes. Seek out teachers, scientists, or mathematicians from underrepresented groups as resources for your classroom.

6. Use technology that is accessible for all.

Select technology programs and online resources that are age appropriate and accessible to students with disabilities. Increasingly, technology products developed for the general population also provide access for disabled users. For example, some word processors now include features such as text-to-speech and word prediction that support students who have difficulties reading and writing or students who are blind. An increasing number of Web sites are accessible to disabled users. But don't take accessibility for granted—new innovations in technology sometimes unwittingly exclude some while including others. For example, the computer mouse makes computer use easier for people who never learned touch-typing, but more difficult for people with cerebral palsy. Similarly, icon-based computer systems were first heralded as more user-friendly than conventional systems, but icon-based systems exclude blind users because these systems don't allow text-to-speech translation.

To identify programs or Web sites that can be used by all students in your class, including those with disabilities, look for icons that identify a program or Web site as accessible. You can also use Bobby, a program by the Center for Applied Special Technology. Bobby allows users to test Web sites for accessibility for disabled users. While this program doesn't ensure complete accessibility, it can help you

identify major access barriers, such as the lack of text descriptions for images and other graphics. Blind users rely on such descriptions to access information.

7. Make assistive technology available when necessary.

Assistive technology, such as touch screens, alternate keyboards, switches, head-mounted pointers, word-prediction software, voice input and output technology, and caption decoders may be critical to enhance some students' participation and capacity.

Don't use assistive technologies to compensate for inadequacies in the curriculum but couple technologies with a curriculum that is accessible to all. For example, don't set up a curriculum that relies heavily on print-only media because a blind student can access that information only through Braille. Instead, use more electronic media—with described images and text that can be read out loud—to change the way information is presented.

Assistive technologies can benefit nondisabled as well as disabled students. For example, while closed captions provide deaf students with access to narration, dialogue, and other sounds in television and video programs, captions also can improve the comprehension of video material for hearing students. Try to make assistive devices available to all so that the technology doesn't set students with disabilities apart, and so every student benefits from the technology.

8. Emphasize cooperation and collaboration.

Have students work in mixed-ability groups where each student can use his or her strengths. Students will need your help and guidance to become independent learners and to build a community of learners among themselves. You may need to engineer the groups to balance talents that complement one another. You may also need to give attention to group processes, such as the roles played by different group members and the experiences students have within these groups. Make sure that all students are actively involved and are rotating roles, so that, for example, the girls aren't always observing while the boys manipulate materials.

Professional Development for Equity

We can prepare ourselves through information and resources to support every child's achievement. Learn how to create accessible learning environments for your students, how to use materials and technology that are accessible to everyone, how to use teaching strategies to address diverse students' needs, and how to use methods and strategies for informal and formal assessment.

You don't have to go far to learn these skills. Take advantage of what your colleagues know, and form cross-disciplinary teams. Seek out colleagues, both within your immediate school community and in the wider education and scientific communities, and build informal and formal collaborations. Form partnerships that include other elementary school teachers, special educators, science specialists, equity experts, and colleagues or experts from underrepresented groups. Collaborative teaching arrangements that involve special education and general education teachers can be especially effective. (See pages 14–18 for further suggestions on professional development and the *Standards*.)

Early childhood teachers often have useful strategies that translate well into the elementary science classroom. The early childhood classroom is typically set up with stations where children have choices about what to do and what materials to use. The materials are arranged to be easily accessible to the children—at the right height, labeled with symbols or language that the child can understand, and organized to reflect and communicate some system of classification. Children have ownership of the room and the materials and are able to initiate activities and

Assistive Technology

The following organizations have more information about assistive technology.

ABLEDATA
8401 Colesville Road, Suite 200
Silver Spring, MD 20910
TEL 800-227-0216
TTY 301-608-8912
FAX 301-608-8958
EMAIL adaigle@aol.com
http://www.abledata.com/

ABLEDATA is a national database of assistive technology and rehabilitation equipment.

Alliance for Technology Access (ATA)
2175 East Francisco Boulevard, Suite L
San Rafael, CA 94901
TEL 415-455-4575
TTY 415-455-0491
FAX 415-455-0654
EMAIL atainfo@ataccess.org
http://www.ataccess.org/

ATA is a national network of community technology centers that provide information and support services to children and adults with disabilities. ATA offers training and hands-on opportunities to use assistive technology.

National Center to Improve Practice (NCIP)
c/o Education Development Center
55 Chapel Street
Newton, MA 02160
TEL 617-969-7100
http://www2.edc.org/NCIP/

NCIP promotes the effective use of technology to enhance educational outcomes for students with sensory, cognitive, physical and social/emotional disabilities. The NCIP Web site includes information about the use of technology for students with disabilities.

Rehabilitation Engineering and Assistive Technology Society of North America (RESNA)
Technical Assistance Project
1700 North Moore Street, Suite 1540
Arlington, VA 22209
TEL 703-524-6686
TTY 703-524-6639
FAX 703-524-6630
EMAIL info@resna.org
http://www.resna.org/

RESNA is an interdisciplinary association of people with an interest in technology and disability. Its purpose is to improve the potential of people with disabilities to achieve their goals through the use of technology. Contact RESNA to locate the Assistive Technology Project in your state. These projects provide information about purchasing and using assistive technology.

Trace Research and Development Center
University of Wisconsin-Madison
5901 Research Park Boulevard
Madison, WI 53719-1252
TEL 608-262-6966
TTY 608-263-5408
FAX 608-262-8848
EMAIL web@trace.wisc.edu
http://www.trace.wisc.edu/

The Trace Center at the University of Wisconsin-Madison is a research and development facility that focuses on making information technologies more accessible for everyone through the process known as universal, or accessible, design. The Center's Web site contains a wealth of information about accessible design and assistive technology.

pursue open-ended investigation. In turn, teachers can observe the children's inquiry and support investigations through questions that are directly related to the questions children are pursuing at the moment. From there, teachers may be able to identify what a child knows and what question or activity might take the student to the next level of understanding.

In the same way, we can draw on lessons from early-intervention specialists who work with young children with developmental disabilities. These specialists are attuned to the developmental steps in a given learning task, and are able to break things down into component parts. They focus on supporting physical as well as cognitive development, and their

classrooms are often set up to encourage children to use their senses fully, even if one or more of those senses is impaired. Activities reinforce basic concepts such as cause-and-effect (e.g., using busyboxes, pushing an object off a table and watching it fall, building a structure and knocking it down, exploring object permanence), and the idea that something exists even when it is hidden from view (e.g., peekaboo and other hiding games). Most children develop these understandings in the first years of life, but children with developmental delays may need help making the connections between the physical world and cognitive identification. In both cases, these concepts are essential to understanding science.

In addition to collaborating with your school district and local universities, you can get information and participate in professional development opportunities through a variety of national organizations. The organizations listed to the right offer information, resources, and workshops on how to engage underrepresented groups in science and mathematics education. Many resources and workshops are available on the Internet.

Student Assessment

Assessment is a key aspect of teaching and learning in an inquiry classroom. It is also central to teaching a diverse group of students. Assessment ensures that learning builds on prior understanding—which may differ from student to student—and that students actually acquire the desired knowledge and skills.

Informal and formal assessments of individual students help you determine whether the needs of each student are addressed, and if all students are making progress towards the learning goals outlined in the *Standards*. Check that the assessments themselves are unbiased and equitable. The following strategies can help you make assessments.

Engaging Underrepresented Groups in Science Education

The following organizations provide information, resources, and professional development opportunities on how to engage underrepresented groups in science education:

American Association for the Advancement of Science (AAAS)
Education and Human Resources Program
1200 New York Avenue, NW
Washington, DC 20005
TEL 202-326-6400
EMAIL webmaster@aaas.org
http://www.aaas.org/

AAAS disseminates print and Internet materials on equity in science education, including materials from the Collaboration for Equity. These materials help teachers delve more deeply into how to create equitable environments and curricula, provide workshop designs and professional development activities, and offer tips for moving equity into the mainstream. AAAS' Roadmaps and Rampways project examines the factors that have influenced the career paths of disabled students in science, engineering and technology.

Disabilities, Opportunities, Internetworking & Technology (DO-IT)
University of Washington
Box 354842
Seattle, WA 98195-4842
TEL/TTY 206-685-DOIT (3648)
FAX 206-221-4171
EMAIL doit@u.washington.edu
http://www.washington.edu/doit/

The DO-IT Program at the University of Washington serves to increase the participation of individuals with disabilities in challenging academic programs and careers, and promotes the use of computer and networking technologies to increase independence, productivity, and participation of people with disabilities in education and employment. DO-IT sponsors programs and delivers presentations and workshops to enhance the lives of people with disabilities throughout the world. DO-IT activities are hosted at conferences, universities, K–12 schools, corporations, state agencies, and professional organizations. DO-IT Internet resources are designed to facilitate communication and provide access to information.

Engaging Underrepresented Groups in Science Education

The Center for Curriculum Innovation
Lawrence Hall of Science (LHS)
University of California at Berkeley
Berkeley, CA 94720-5200
TEL 510-642-1823
EMAIL lhsinfo@uclink.berkeley.edu
http://www.lhs.berkeley.edu/centers.html

The Center for Curriculum Innovation develops instructional materials and professional development methods that translate experience, research, theory, and the *Standards* into exciting learning experiences. LHS programs, including EQUALS, Family Math, FOSS, GEMS, and MARE, provide ongoing support through innovative materials and methods.

The Council for Exceptional Children (CEC)
1920 Association Drive
Reston, VA 20191-1589
TEL 1-888-CEC-SPED (232-7733)
TTY 703-264-9446
FAX 703-264-9494
EMAIL cec@cec.sped.org
http://www.cec.sped.org/

CEC is an international professional organization dedicated to improving educational outcomes for students with disabilities and the gifted. It disseminates information about teaching exceptional students through its Web site, print and video materials, and annual conference. CEC also offers opportunities for continuing education through online and onsite workshops.

The Education Trust
1725 K Street, Suite 200
Washington, DC 20006
TEL 202-293-1217
FAX 202-293-2605
http://www.edtrust.org/

The Education Trust promotes high academic achievement for all students, kindergarten through college. The Education Trust disseminates information about *Standards*-based education for underrepresented groups through print, the Web, and conferences.

Eisenhower National Clearinghouse (ENC)
1929 Kenny Road
Columbus, OH 43210-1079
TEL 800-621-5785
FAX 614-292-2066
EMAIL info@enc.org
http://www.enc.org/

ENC's mission is to identify effective curriculum resources, create high-quality professional development materials, and disseminate information and products to improve K–12 mathematics and science teaching and learning. ENC is funded by the U.S. Department of Education's Office of Educational Research and Improvement.

The National Center on Accessing the General Curriculum
Center for Applied Special Technology (CAST)
39 Cross Street, Suite 201
Peabody, MA 01960
TEL 978-531-8555
TTY 978-538-3110
FAX 978-531-0192
EMAIL: cast@cast.org
http://www.cast.org/

The National Center on Accessing the General Curriculum is funded by the U.S Department of Education and is a collaboration of the Harvard University Children's Initiative/Harvard Law School, Boston College, CAST, and CEC. The goals of the Center are to build a unified knowledge base and to develop and disseminate a new vision and practical approaches for providing disabled students with access to the general curriculum.

Science Education for Students with Disabilities (SESD)
c/o Judy Egelston-Dodd, President
Office of Faculty & Staff Development
National Technical Institutes for the Deaf at RIT
52 Lomb Memorial Drive
Rochester, NY 14623
TEL 716-475-6932
FAX 716-475-6400
http://www.as.wvu.edu/~scidis/organizations/sepd_main.html

SESD promotes and advances the teaching of science and the development of curricula and instructional materials for disabled students at all levels. SESD publishes *The Journal of Science for Persons with Disabilities*, hosts annual meetings in conjunction with the conventions of the National Science Teachers Association, and co-sponsors a teacher of the year award in science education for students with disabilities.

The Women's Educational Equity Act (WEEA) Equity Resource Center
Education Development Center
55 Chapel Street
Newton, MA 02458-1060
TEL 800-225-3088
TTY 800-354-6798
FAX 617-332-4318
EMAIL weeactr@edc.org
http://www.edc.org/WomensEquity/

WEEA Equity Resource Center works to improve educational, social, and economic outcomes for women and girls. The WEEA Center disseminates print materials, offers online workshops, and manages the Educational Equity Discussion List (EDEQUITY), an international electronic discussion about all aspects of educational equity.

1. Don't infer what students can do based on their group membership.

It is important to understand the obstacles and differential opportunities faced by some groups so that you can counter societal stereotypes and discrimination. Your knowledge of which groups a student belongs to can help you in your informal assessments, but don't automatically attribute group characteristics to an individual. Base your decisions about what learning experience a student should have on what the student brings to the classroom, not on assumptions about his or her group membership.

There are no "one size fits all" approaches to learning. Different instructional strategies will work with different students. Constant observation of what students bring to the classroom, and continuous analysis of where students are in relation to the desired learning goals, can help to ensure that each student's needs are met.

2. Include all students in assessments.

The only way to gauge if all students achieve the learning goals outlined in the *Standard*s is to have all students participate in the assessment. Yet students with disabilities are often "excused" from assessments. As a result, teachers don't have an accurate picture of students' learning and can't draw conclusions about student progress or ensure that the appropriate educational entity—class, school, district, or government—is meeting its obligations for educating all children.

It is true that some national, state, and district assessments may not be appropriate or valid measures of *Standards*-based science learning for all students. Tests should be accessible, unbiased, and valid, but they often are not. Until tests are accessible for all students, we should consider how to provide accommodations and help the child with testing to provide a foundation of good information from which to take action.

3. Use assessment methods that are accessible for all students.

In your own classroom, there is much you can do to include all students in assessment. Give students a number of ways to show what they have learned. Encourage students to develop hands-on demonstrations, write narratives, put on plays, make recordings, create artwork, use photography and video, and design multimedia reports on the computer. Take clues from these presentations about what enables different students to show off their knowledge, and construct assessments that give students choices of materials and approaches.

Accommodate students for whom the assessment cannot be made accessible, by providing assistive technology or more time. Teachers often worry that accommodations such as extra time on a test are unfair, but extra time is fair unless the test measures how quickly a student can complete a science task. The accommodations simply make it possible for every student to demonstrate what he or she knows and is able to do.

Selecting Content

The context in which you put the science content, the way you choose what topics to focus on, and the relationship of the "nature of the learner" to the choice and delivery of content are key considerations in reaching all students.

1. Recognize variation in the "nature of the learner."

As an educator who works with children in the elementary grades, you are well aware of the many developmental changes taking place in children between the ages of 5 and 11. Development takes place on many different levels and encompasses physical, social, emotional, and cognitive changes, for disabled and nondisabled students. Development is influenced by many factors including socialization, experiences, resources, opportunity, and the child's individual physical makeup.

Test Accommodations

The following resources have more information about test accommodations for students with disabilities and limited English proficiency.

The National Center on Educational Outcomes (NCEO)
University of Minnesota
350 Elliott Hall
75 East River Road
Minneapolis, MN 55455
TEL 612-626-1530
FAX 612-624-0879
http://www.coled.umn.edu/NCEO/

NCEO provides national leadership in the participation of students with disabilities and limited English proficient (LEP) students in national and state assessments, standards-setting efforts, and graduation requirements.

Thurlow, Martha L., Elliot, Judith L., and **Ysseldyke, James E.** (1997). *Testing Students with Disabilities: Practical Strategies for Complying with District and State Requirements.* Thousand Oaks, CA: Corwin Press, Inc.

As you select curriculum topics and methods, consider that your class may have students who are different from or do things differently than as predicted by the standard developmental schema.

Students may be at very different levels of capacity on key science concepts such as cause-and-effect, or key science skills such as inquiry. Cause-and-effect is an abstract concept, and children who are concrete thinkers, who have developmental disabilities, or have less experience observing physical phenomena may benefit from physical prompts and explicit connections, even as you encourage an open-ended exploration process.

Similarly, consider how to make the inquiry process available to all students. Some children have more experience guessing and imagining "what will happen if..." Part of this depends on students' grasp of how the past, present, and future differ, and their ability to project an action in their minds into some future time. Some children will benefit by permission to wonder out loud and pursue their own path, while other students will get stuck on the first step. Try scaffolding the experience—what if you start with this? And add this? And try that?

Sometimes children answer a different question from the one they were asked. Try asking the question that they answered. This can affirm their thinking, and also help children to see the connections between questions and answers. This connection may be especially important for children who have trouble answering "why" questions (perhaps because they are not ready for that level of abstraction or generalization) or "when" questions (because their sense of past, present, and future is not yet well developed).

2. Capitalize on different ways of perceiving the physical world.

Our perspective on the physical world is determined by where we stand and sit, by how we see, hear, and touch, and how we translate those experiences into general constructs. Altering our perspective provides additional insights into our understanding, and good scientific method advises us to look at the world from different angles, to turn questions and ideas upside down, and to verify our observations in multiple ways. The range of different experiences, perspectives, and interests represented in a diverse classroom can help to enhance science learning for everyone.

People with disabilities often devise innovative ways of exploring materials and their environment with senses, parts of the body, and creative instruments. Wheelchair users may have a different perspective than those who view the world by standing. Similarly, rolling in a wheelchair rather than walking can foster an intuitive important understanding of gravity, speed, and friction.

3. Support students to pursue questions that particularly intrigue them.

NSTA Pathways to the Science Standards emphasizes building on a child's prior interests and understandings. These interests and understandings are influenced not just by the child's individual characteristics, but also by demographic factors such as culture, socioeconomic status, race, ethnicity, and gender.

Children make sense of the world with the tools and resources available to them. All cultures have systematic ways of interpreting the meaning of the physical world, or classifying and understanding scientific phenomena. The explanations and concepts students are introduced to through the *Standards* may support or contrast with their own ways of organizing the world. The more you understand the origin of a student's ideas, the better you can construct a science experience that takes advantage of the student's background knowledge.

Identifying a question worth pursuing is a key science skill. Encourage each child to articulate questions within a topic about which he or she wants to know more. Value each question as a reflection of the child's prior experience and background. Help children to go beyond their worldviews, to embrace questions by peers and you. It may not always be possible to find questions in which every student in your class will be interested, and a particular student's interest may not be perfectly addressed in every inquiry you undertake. But over the course of the school year, seek a balance so that each student has the opportunity to make personal connections to science.

4. Allow for multiple entry points and a flexible content sequence.

There may not be one linear sequence that will work for all of your students. Based on the unique experiences, abilities, and prior understandings that students bring to the classroom, they may need different entry points. Try to keep the instructional sequence

Equity in Science Education

The following materials have been developed to enhance equity in science education. They provide teaching strategies, assessments, and ideas for problems and themes to investigate with your students.

Eisenhower National Clearinghouse. (1998). Multicultural Approaches in Math and Science. *ENC Focus for Mathematics and Science Education*, 5 (1).

George, Yolanda S., Malcom, Shirley M., and **Worthington, Valerie L.** (Eds.) (1995). *In Touch with Preschool.* Washington, DC: American Association for the Advancement of Science.

George, Yolanda S., Sosa, Maria, and **Bowden, Gaynelle.** (Eds.) (1997). *In Touch with Community Service Learning: A Guide to Hands-on Science.* Washington, DC: American Association for the Advancement of Science.

Lawrence Hall of Science. (1987). *Full Option Science System (FOSS).* Chicago: Encyclopedia Britannica Educational Corporation.

Matyas, Marsha L. and **Triana, Estrella M.** (Eds.) (1995). *In Touch with Electricity.* Washington, DC: American Association for the Advancement of Science.

Matyas, Marsha L. and **Triana, Estrella M.** (Eds.) (1995). *In Touch with Magnetism.* Washington, DC: American Association for the Advancement of Science.

Matyas, Marsha L. and **Triana, Estrella M.** (Eds.) (1995). *In Touch with Mathematics.* Washington, DC: American Association for the Advancement of Science.

Rethinking Schools. (1994). *Rethinking Our Classrooms: Teaching for Equity and Justice.* Milwaukee, WI: Author.

Shulman, Judith H., and **Mesa-Bains, Amalia.** (1993). *Diversity in the Classroom: A Casebook for Teachers and Teacher Educators.* Hillsdale, NJ: Research for Better Schools and Lawrence Erlbaum Association.

Sprung, Barbara, Froschl, Merle, and **Colon, Linda.** (1997). *Playtime is Science: An Equity-Based Parent/Child Science Program.* New York: Educational Equity Concepts.

Stern, Valerie, et al. (1998). *Access Science: Themes and Variations*. Washington, DC: American Association for the Advancement of Science.

Tunstall Margaret E., and **Matyas, Marsha L.** (Eds.) (1995). *In Touch with Girls and Science.* Washington, DC: American Association for the Advancement of Science.

flexible and provide multiple opportunities to approach a given science topic. This is not easy to do in a class of 30 or more diverse students, but consider strategies such as using computer and online explorations and setting up learning stations with hands-on activities that students can use independently.

Programs and Systems that Support all Learners

The program standards emphasize what has been discussed throughout this appendix: that a good program is designed around student knowledge, skills, and attitudes, that inquiry is key, and that diverse learners should have equal resources and opportunity to learn. Developing an equitable and coherent program requires a coordinated effort involving all parts of the educational enterprise.

Teachers play critical roles within this larger effort. As an innovator and program developer at the classroom and school level, you are building a repertory of strategies that work with a broad range of students and that can be shared with other teachers, parents, administrators, and policymakers. You know what makes a diverse classroom work, and you can advocate for adequate resources, assistive technology, collaborative planning time, and attention in every part of the educational system to meet the needs of all learners.

A teacher's most important role may be as program evaluator to assess progress in creating a high-quality learning environment for all students. A teacher's goal is to determine what works for whom: what approaches are effective with which students? Are there differences in participation and achievement by group membership? Ideally, these measures will be connected to similar, data-based efforts at the school, district, and state levels. Such efforts can guide decisions about curriculum, teaching, professional development, and assessment. These decisions are based not on their effectiveness for average students, but on their effectiveness for different groups of students, and ultimately for all students.

In a school providing high-quality education, demographics should not determine outcomes. If students' achievement can be predicted by variables such as residency or family income, then the system is not treating students fairly and must be changed.

We must continue to dismantle these artificial barriers to participation and achievement. This part may be easier said than done. But it is essential to preparing today's children for the scientific and technological challenges of the twenty-first century, and for ensuring the health of science education and the scientific enterprise.

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RESOURCES FOR THE ROAD

Grandin, Temple. (2000). *My Experiences with Visual Thinking, Sensory Problems, and Communication Difficulties*. Salem, OR: Center for the Study of Autism. Available at <http://www.autism.org/temple/visual.html>.

Grandin, Temple. (2000). *Teaching Tips for Children and Adults with Autism*. Salem, OR: Center for the Study of Autism. Available at <http://www.autism.org/temple/tips.html>.

Malcom, Shirley M. (1994). Science for All: Easy to Say, Hard to Do. In A. Pendergast, ed., *In Pursuit of Excellence: National Standards for Science Education. Proceedings of the 1992 AAAS Forum for School Science*. Washington, DC: American Association for the Advancement of Science.

Vermeij, Geerat J. (1998). *Privileged Hands*. New York: W. H. Freeman & Co.